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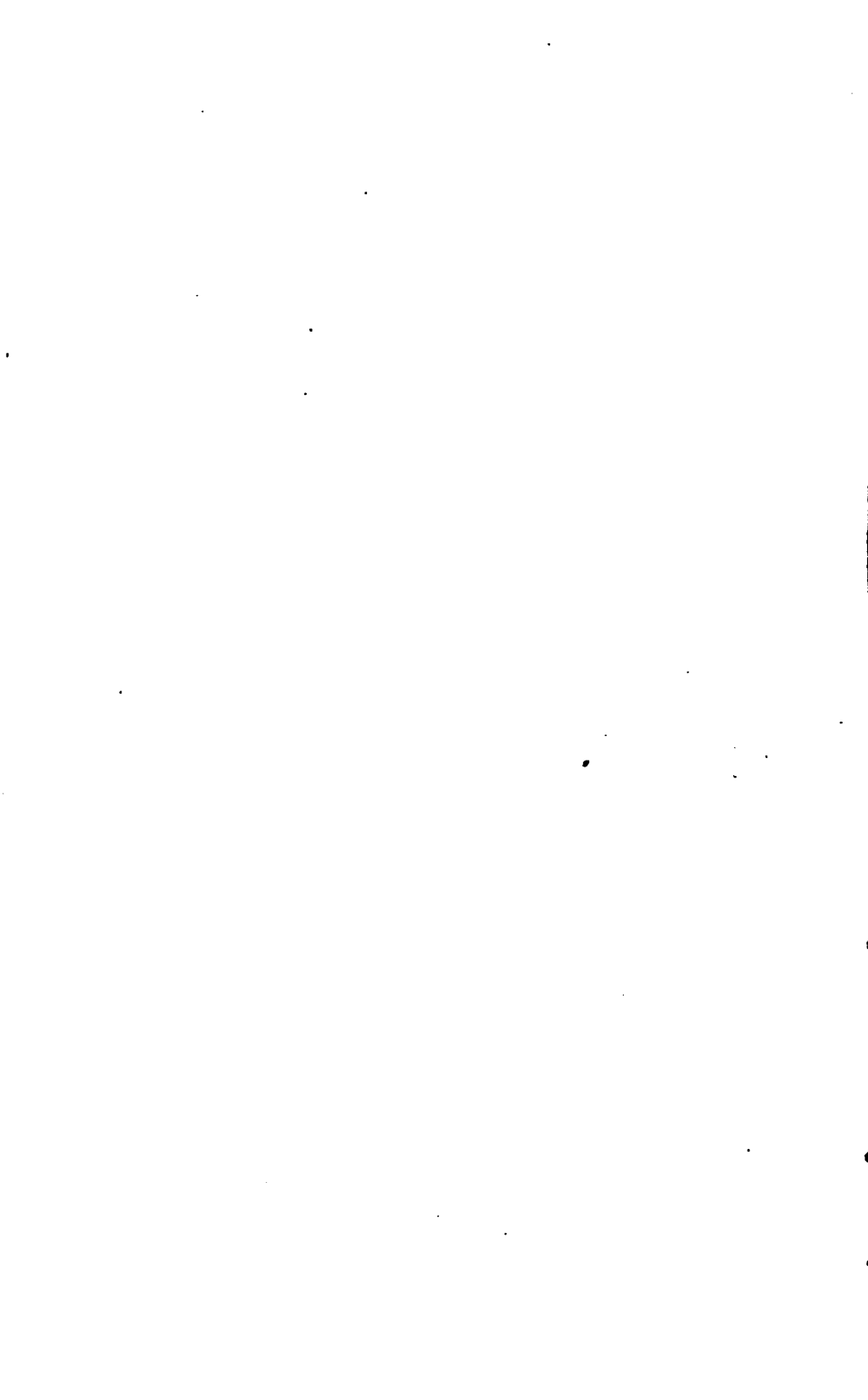
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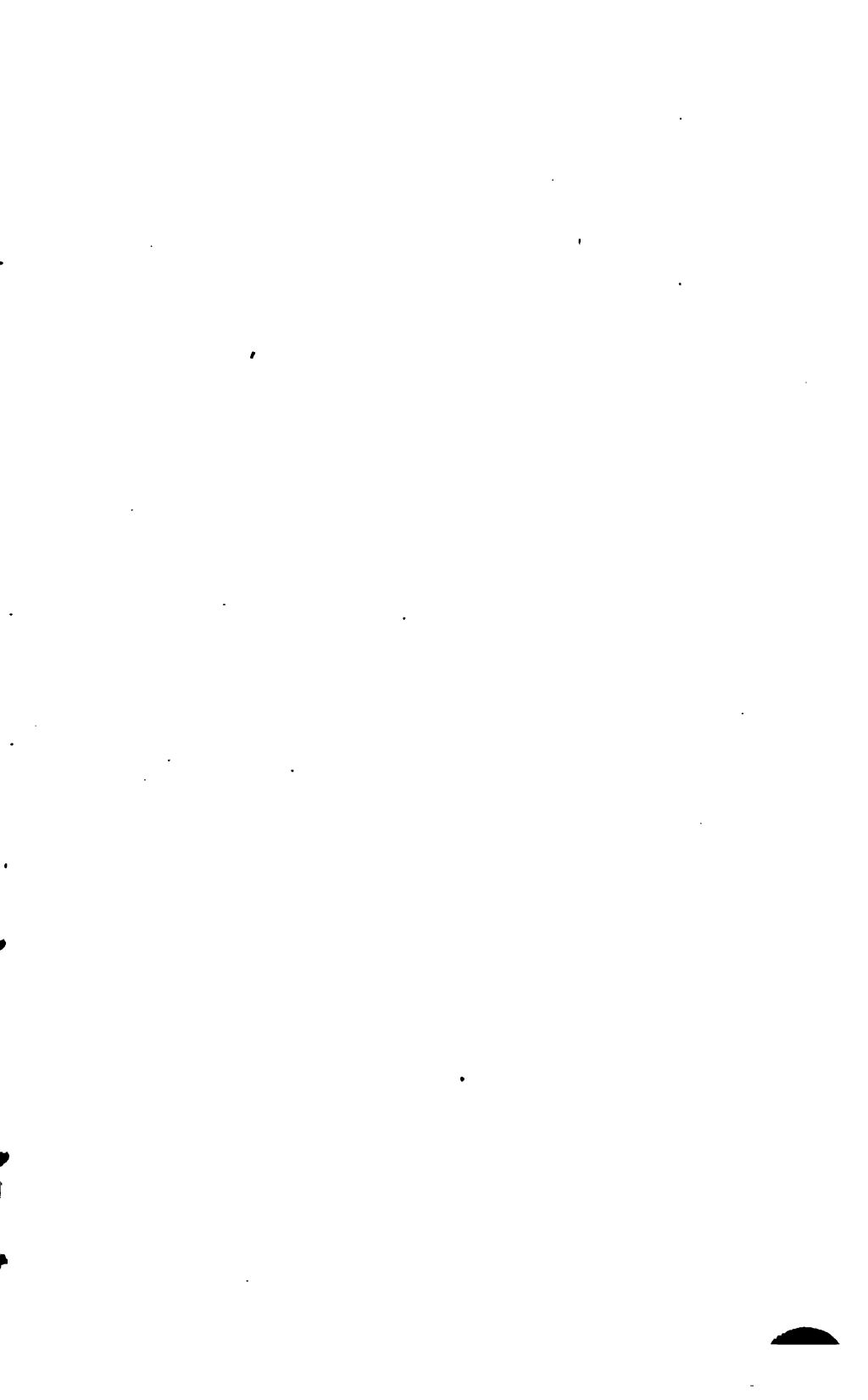
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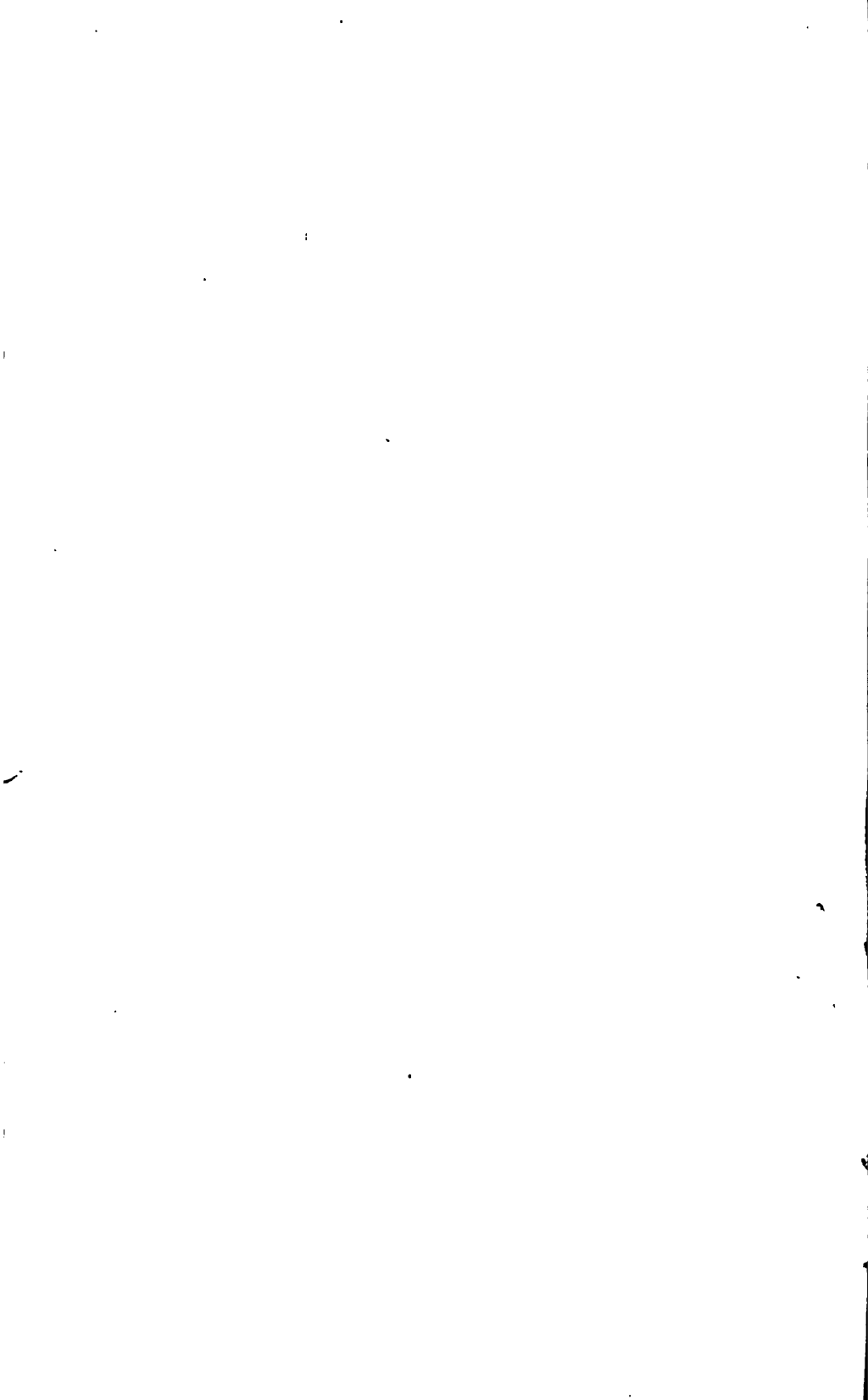
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Edward C. Pickering.







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A

DICTIONARY

OF

ARTS, MANUFACTURES, AND MINES:

CONTAINING

A CLEAR EXPOSITION OF THEIR PRINCIPLES AND PRACTICE.

BY ANDREW URE, M.D.

F.R.S. M.G.S. M.A.S. LOND.; M. ACAD. N.S. PHILAD.; S. PH. SOC. N. GERM. HANOV.; MULII. ETC. ETC.

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A

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ARTS, MANUFACTURES, AND MINES.

K.

KALL. The Arabs gave this name to an annual plant which grows near the sea-shore; now known under the name of *salsola soda*, and from whose ashes they extracted a substance, which they called *alkali*, for making soap. The term *kali* is used by German chemists to denote caustic potash; and *kalium*, its metallic basis; instead of our *potassa* and *potassium*, of preposterous pedigree, being derived from the words *pot ashes*, that is ashes prepared in a pot.

KAOLIN, (*Terre à porcelaine*, Fr.; *Porzellanerde*, Germ.), is the name given by the Chinese to the fine white clay with which they fabricate the biscuit of their porcelains. See **CLAY**. Berthier's analyses of two porcelain earths are as follows:—

| Analyses. | From Passau. | From Saint Yrieux. |
|-----------------------|--------------|--------------------|
| Silica - - - - | 45.06 | 46.8 |
| Alumina - - - - | 32.00 | 37.3 |
| Lime - - - - | 0.74 | — |
| Oxide of iron - - - - | 0.90 | — |
| Potass - - - - | — | 2.5 |
| Water - - - - | 18.0 | 13.0 |
| | 96.7 | 99.6 |

KARABE', a name of amber, of Arabic origin, in use upon the Continent.

KELP; (*Varec*, Fr.; *Waresch*, Germ), is the crude alkaline matter produced by incinerating various species of fuel, or *sea-weed*. They are cut with sickles from the rocks in the summer season, dried and then burned, with much stirring of the pasty ash. I have analyzed many specimens of kelp, and found the quantity of soluble matter in 100 parts of the best to be from 53 to 62, while the insoluble was from 47 to 38. The soluble consisted of—

| | | | | | |
|------------------------------------|---|---|---|------|------|
| Sulphate of soda - - - - | - | - | - | 8.0 | 19.0 |
| Soda in carbonate and sulphuret | - | - | - | 8.5 | 5.5 |
| Muriate of soda and potash - - - - | - | - | - | 36.5 | 37.5 |
| | | | | 53.0 | 62.0 |

The insoluble matter consisted of—

| | | | | | |
|--|---|---|---|-------|-------|
| Carbonate of lime - - - - | - | - | - | 24.0 | 10.0 |
| Silica - - - - | - | - | - | 8.0 | 0.0 |
| Alumina tinged with iron oxide - - - - | - | - | - | 9.0 | 10.0 |
| Sulphate of lime - - - - | - | - | - | 0.0 | 9.5 |
| Sulphur and loss - - - - | - | - | - | 6.0 | 8.5 |
| | | | | 100.0 | 100.0 |

The first of these specimens was from Heisker, the second from Rona, both in the Isle of Skye, upon the property of Lord Macdonald. From these and many other

analyses which I have made, it appears that kelp is a substance of very variable composition, and hence it was very apt to produce anomalous results, when employed as the chief alkaline flux of crown glass, which it was for a very long period. The *fucus vesiculosus* and *fucus nodosus* are reckoned to afford the best kelp by incineration; but all the species yield a better product when they are of two or three years growth, than when cut younger. The *carac*, made on the shores of Normandy, contains almost no carbonate of soda, but much sulphate of soda and potash, some hyposulphite of potash, chloride of sodium, iodide of potassium, and chloride of potassium; the average composition of the soluble salts being, according to M. Gay Lussac, 56 of chloride of sodium, 25 of chloride of potassium, and a little sulphate of potash. The very low price at which soda ash, the dry crude carbonate from the decomposition of sea salt, is now sold, has nearly superseded the use of kelp, and rendered its manufacture utterly unprofitable—a great misfortune to the Highlands and Islands of Scotland.

KERMES. There are two substances so called, of totally different natures. *Kermes mineral* is merely a factitious sulphuret of antimony in a state of impalpable comminution, prepared in the moist way. Its minute examination belongs to pharmaceutical chemistry. It may be obtained perfectly pure, by diluting the proto-chloride of antimony with solution of tartaric acid, and precipitating the metal with sulphuretted hydrogen; or by exposing the finely levigated native sulphuret to a boiling solution of carbonate of potash for some time, and filtering the liquor while boiling hot. The kermes falls down in a brown-red powder, as the liquor cools.

Kermes-grains, *alkermes*, are the dried bodies of the female insects of the species *coccus ilicis*, which lives upon the leaves of the *quercus ilix* (prickly oak). The word *kermes* is Arabic, and signifies little worm. In the middle ages, this dye stuff was therefore called *vermiculus* in Latin, and *vermillion* in French. It is curious to consider how the name *vermillion* has been since transferred to red sulphuret of mercury.

Kermes has been known in the East since the days of Moses; it has been employed from time immemorial in India to dye silk; and was used also by the ancient Greek and Roman dyers. Pliny speaks of it under the name of *coccigrassum*, and says that there grew upon the oak in Africa, Sicily, &c. a small excrescence like a bud, called *escudium*; that the Spaniards paid with these grains half of their tribute to the Romans; that those produced in Sicily were the worst; that they served to dye purple; and that those from the neighbourhood of Emerita in Lusitania (Portugal) were the best.

In Germany, during the ninth, twelfth, thirteenth, and fourteenth centuries, the rural serfs were bound to deliver annually to the convents a certain quantity of kermes, the *coccus polonicus*, among the other products of husbandry. It was collected from the trees upon Saint John's day, between eleven o'clock and noon, with religious ceremonies, and was therefore called *Johannisblut*, (Saint John's blood), as also German cochineal. At the above period, a great deal of the German kermes was consumed in Venice, for dyeing the scarlet to which that city gives its name. After the discovery of America, cochineal having been introduced, began to supersede kermes for all brilliant red dyes.

The principal varieties of kermes are the *coccus quercus*, the *coccus polonicus*, the *coccus fragaria*, and the *coccus vva ursi*.

The *coccus quercus* insect lives in the south of Europe upon the kermes oak. The female has no wings, is of the size of a small pea, of a brownish-red colour, and is covered with a whitish dust. From the middle of May to the middle of June the eggs are collected, and exposed to the vapour of vinegar, to prevent their incubation. A portion of eggs is left upon the tree for the maintenance of the brood. In the department of the Bouches-du-Rhone, one half of the kermes crop is dried. It amounts annually to about 60 quintals or cwts., and is warehoused at Avignon.

The kermes of Poland, or *coccus polonicus*; is found upon the roots of the *scleranthus perennis* and the *scleranthus annuus*, in sandy soils of that country and the Ukraine. This species has the same properties as the preceding; one pound of it, according to Wolfe, being capable of dyeing 10 pounds of wool; but Hermstaedt could not obtain a fine colour, although he employed 5 times as much of it as of cochineal. The Turks, Armenians, and Cossacks, dye with kermes their morocco leather, cloth, silk, as well as the manes and tails of their horses.

The kermes called *coccus fragaria* is found principally in Siberia, upon the root of the common strawberry.

The *coccus vva ursi* is twice the size of the Polish kermes, and dyes with alum a fine red. It occurs in Russia.

Kermes is found not only upon the *lycopodium complanatum* in the Ukraine, but upon a great many other plants.

Good kermes is plump, of a deep red colour, of an agreeable smell, and a rough and pungent taste. Its colouring matter is soluble in water and alcohol; it becomes yellowish or brownish with acids, and violet or crimson with alkalis. Sulphate of iron

blackens it. With alum it dyes a blood-red; with copperas, an agate gray; with copperas and tartar, a lively gray; with sulphate of copper and tartar, an olive green; with tartar and salt of tin, a lively cinnamon yellow; with more alum and tartar, a lilac; with sulphate of zinc and tartar, a violet. Scarlet and crimson dyed with kermes were called *grain colours*; and they are reckoned to be more durable than those of cochineal, as is proved by the brilliancy of the old Brussels tapestry.

Hellot says that previous to dyeing in the kermes bath, he threw a handful of wool into it, in order to extract a blackish matter, which would have tarnished the colour. The red caps for the Levant are dyed at Orleans with equal parts of kermes and madder; and occasionally with the addition of some Brasil wood.

Cochineal and lac-dye have now nearly superseded the use of kermes as a tinctorial substance in England.

KILLAS. The name given by the Cornish miners to *clay slate*, commonly of a greenish colour, in which the richest deposits of copper and tin occur.

KILN; (*Four*, Fr.; *Ofen*, Germ.) is the name given to various forms of furnaces and stoves, by which an attempered heat may be applied to bodies; thus there are brick-kilns, hop-kilns, lime-kilns, malt-kilns, pottery-kilns. Hop and malt-kilns, being designed merely to expel the moisture of the vegetable matter, may be constructed in the same way. See **BRICK**, **LIMESTONE**, **MALT**, **POTTERY**, for a description of their respective kilns.

KINIC ACID; a peculiar acid extracted by Vauquelin from cinchona.

KINO, is an extractive matter obtained from the *nauclea gambir*, a shrub which grows at Bancoul and Sumatra, but principally in Prince of Wales' Island. It is of a reddish-brown colour, has a bitter styptic taste, and consists chiefly of tannin. It is used only as an astringent in medicine. Kino is often called a gum, but most improperly.

KIRSCHWASSER, is an alcoholic liquor obtained by fermenting and distilling bruised cherries, called *kirschchen* in German. The cherry usually employed in Switzerland and Germany is a kind of morello, which on maturation becomes black, and has a kernel very large in proportion to its pulp. When ripe, the fruit being made to fall by swithing the trees, is gathered by children, thrown promiscuously, unripe, ripe, and rotten into tubs, and crushed either by hand, or with a wooden beater. The mashed materials are set to ferment, and whenever this process is complete, the whole is transferred to an old still covered with verdigris, and the spirit is run off in the rudest manner possible, by placing the pot over the common fireplace.

The fermented mash is usually mouldy before it is put into the alembic, the capital of which is luted on with a mixture of mud and dung. The liquor has accordingly, for the most part, a rank smell, and is most dangerous to health, not only from its own crude essential oil, but from the prussic acid, derived from the distillation of the cherry-stones.

There is a superior kind of *kirschwasser* made in the Black Forest, prepared with fewer kernels, from choice fruit, properly pressed, fermented, and distilled.

KNOPPERN, are excrescences produced by the puncture of an insect upon the flower-cups of several species of oak. They are compressed or flat, irregularly pointed, generally prickly and hard; brown when ripe. They abound in Styria, Croatia, Slavonia, and Natolia; those from the latter country being the best. They contain a great deal of tannin, are much employed in Austria for tanning, and in Germany for dyeing fawn, gray, and black. Wool, with a mordant of sulphate of zinc, takes a grayish nankeen colour. See **GALLA**.

KOUMISS, is the name of a liquor which the Calmucs make by fermenting mare's milk, and from which they distil a favourite intoxicating spirit, called *rack* or *racky*. Cow's milk is said to produce only one third as much spirit, from its containing probably less saccharine matter.

The milk is kept in bottles made of hides till it becomes sour, is shaken till it casts up its cream, and is then set aside in earthen vessels in a warm place to ferment, no yeast being required, though sometimes a little old koumiss is added. 21 pounds of milk put into the still afford 14 ounces of low wines, from which 6 ounces of pretty strong alcohol, of an unpleasant flavour, are obtained by rectification.

L.

LABDANUM or **LADANUM**, is an unctuous resin, of an agreeable odour, found besmearing the leaves and twigs of the *cistus creticus*, a plant which grows in the island of Candia, and in Syria. It is naturally a dark-brown soft substance, but it hardens on keeping. Its specific gravity is 1.186. It has a bitter taste. Its chief use is in surgery for making plasters.

LABOUR SAVING MACHINES IN THE GREAT EXHIBITION.—*Printing and numbering Cards.*—It will be remembered, that in the early days of railway travelling, the ticket system then in vogue at the various stations was a positive nuisance; as every ticket before it was delivered to a passenger had to be stamped, and torn out of a book,—thus causing the loss of considerable time to travellers when many passengers were congregated. But this was the least evil; for the railway directors had little or no check upon their servants, and therefrom resulted many ingenious and successful frauds. The first to remedy this was Mr. Edmondson, who constructed an ingenious apparatus for printing the tickets with consecutive numbers, and also dating the same. This gave great facilities for checking the accounts of the station clerks; but owing to the imperfect manner of inking, consequent on the construction of the apparatus, the friction to which the tickets were exposed, before they were delivered up, in a great manner obliterated the printing, and occasionally rendered them quite illegible. By Messrs. Church and Goddard's machine for printing, numbering, cutting, counting, and packing railway tickets, this difficulty also is removed, and great speed is attained in manufacturing the tickets, as the several operations which we have enumerated are simultaneously performed. Pasteboard cut into strips by means of rollers, as above explained, is fed into the machine, by being laid in a trough, and brought under the prongs of a fork (working with an intermitting movement), which pushes the strips successively forward between the first pair of a series of guide or carrying rollers. There are four pairs of rollers, placed so as to conduct the strip through the machine in a horizontal line; and an intermittent movement is given them for the purpose of carrying the strips forward a short distance at intervals. The standards of the machine carry, at the top, a block termed the "platten," as it acts the part of the press head in the common printing machine,—portions of it projecting downwards between the upper rollers of the first and second, and second and third, pairs of carrying rollers, nearly to the horizontal plane, in which the pasteboard lies, so as to sustain it at those points while it receives the pressure of the printing types and numbering discs, hereafter referred to. The types to designate the nature of the ticket, as "Birmingham, First Class," are secured in a "chase," upon a metal plate or table, which also carries the numbering discs for imprinting the figures upon the cards; and the table by a cam action is alternately raised, to bring the types and numbering discs in contact with the pasteboard, and then lowered into a suitable position, to admit of an inking roller, moving over the types and numbering discs, and applying ink thereto. The table likewise carries at one end a knife, which acts in conjunction with a knife-edge, projecting downwards from the fixed head of the machine, and thereby gives the cross cut to the strips between the third and fourth pairs of carrying rollers,—thus severing each into a given number of tickets. The strip of pasteboard which is fed into the machine stops on arriving at the second pair of carrying rollers; and, on the ascent of the printing-table, the types print on that portion which is between the first and second pairs of rollers. The strip then passes on to the third pair of rollers, where it stops; and, on the table again ascending, the numbering discs imprint the proper number upon the pasteboard between the second and third pairs; the type, in the meanwhile, printing what is to be the next following ticket. On the next ascent of the table, the strip has advanced to the fourth pair of rollers; and the knives being now brought into contact, the printed and numbered portion of the strip is severed. The now completed ticket is lastly delivered by the fourth pair of rollers into a hollow guide piece, and conducted to a box below, provided with a piston, which, to facilitate the packing of the tickets in the box, can be adjusted to any height to receive the tickets as they fall. To avoid the necessity of having to count the tickets after they are taken from the receiving box, a counting apparatus, connected with the working parts of the machine, is made to strike a bell on the completion of every hundred or more tickets, so as to warn the attendant to remove them from the box. The inking apparatus is assimilated in character to self-acting inkers in ordinary printing presses; and the numbering discs are worked in a manner very similar to those for paging books.

A simple arrangement of apparatus for printing and numbering cards was exhibited by Messrs. Harrild and Sons. The types are fixed in a metal frame, which also carries the numbering discs. This frame is mounted on a rocking shaft, and is furnished with a

handle, whereby it is rocked to bring down the types and discs upon the card, to produce the impression. When the frame is raised again, the units disc is moved forward one figure, and the types are inked by a small roller, which takes its supply of ink from an inking table, that forms the top of the frame. This is a useful description of machine; but the specimen in the Exhibition does not appear to have been properly adjusted, as the figures of the numbering discs have a tendency to cut through the card.

M. Baranowski, of Paris, exhibits a machine for printing and numbering tickets, and also indicating the number printed. The types and numbering discs are carried by a horizontal rotating shaft, upon which, near each end thereof, is a metal disc; and upon the periphery of these discs, a metal frame is affixed, which carries the types and numbering discs, and corresponds in curvature with the edge of the discs. The types for printing the inscription upon the ticket are arranged at right angles to the length of the shaft, which position admits of some lines of the inscription being printed in one colour, and the remainder in another colour. In the type frame a slot or opening is formed lengthwise of the shaft; and behind this opening are three numbering discs, and three discs for indicating the quantity of tickets numbered,—all standing in the same row. The numbering discs are made with raised figures, which project through the slot, in order to print the number upon the ticket; and on the peripheries of the registering discs, (which move simultaneously with their corresponding numbering discs) the figures are engraved. The tickets to be printed and numbered are placed in a rectangular box or receiver, having at the bottom a flat sliding piece, which has a reciprocating motion for the purpose of pushing the lowest ticket out of the box, through an opening in the front side thereof, beneath an elastic pressing-roller of India-rubber; the type frame (with the types and figures properly inked), is at the same time brought, by the rotation of its shaft, into contact with the ticket beneath the pressing roller, and as it continues its motion, it causes the ticket to move forward beneath the pressing roller, and to be properly printed and numbered. The ticket then falls from the machine; and the type frame, carried on by the revolution of the shaft, brings that number on the registering discs, which corresponds with the number printed on the ticket, under a small opening in the case, covered with glass; whereby the number of tickets printed will be indicated.

Backing Books.—Not altogether foreign to the subject of printing is the contribution of Mr. C. Star, of New York, United States, who exhibits two machines for booksellers' use,—the one being employed for backing, and the other for finishing the backs of books. The two machines are similar to each other, as regards the subordinate parts, but differ in some other respects. In the backing machine, the stitched sheets, forming the book, are fixed in a pair of iron clumps, somewhat larger than the book itself. The clumps are mounted on horizontal pivots, and furnished with a weighted lever, which gives them a tendency to move out of the vertical line, and thereby bring the back of the book, which stands up above the edges of the clumps, under the action of a smooth metal roller. This roller turns in bearings which are capable of sliding vertically in the framing of the machine: and the bearings are pressed upon by two weighted levers, when the machine is in use, so as to cause the roller to bear down forcibly upon the book. While the roller is in this position, the weighted lever of the clumps causes the book to oscillate, and thus the rounding of the back is effected. The movement of the clumps under the roller is regulated by the workman through a foot treadle, connected with the lever in the machine for finishing the backs; the roller is engraved with any suitable design; and the cross-piece, which supports its bearings, is made hollow and is heated by steam, for the purpose of communicating heat to the roller. Motion in this case is given to the clump by a winch-handle, instead of the weighted lever, and the pattern on the roller is thereby embossed upon the back of the book.—*Newton's Journal.*

Washing and Mangling.—The British portion of the Great Exhibition contained numerous examples of the application of machinery to economize labour in the processes of washing, wringing, and mangling. The washing machines may be divided into three classes, viz. first, those which have a rotary action; secondly, those wherein vibrating beaters are employed; and thirdly, those in which vertical beaters are ultimately raised and permitted to fall upon the clothes.

In the first class, Mr. V. Price, of Wardour Street, Soho, has a simple machine, consisting of a cylinder or drum, to contain the clothes, revolving horizontally in a close wooden vessel, or outer case, which holds the soap-suds. The drum is made with solid ends; but, (in order that the soap-suds may have free access to the clothes,) the periphery or body thereof is composed of wooden bars or spokes, extending from one end to the other, with a space somewhat greater than the width of a bar between the adjacent bars, so as to resemble what is known to engineers as a "lantern drum." The clothes are introduced by opening a door in the side of the drum; and on rotary motion being given to the drum by a handle, the soap-suds will be caused to act upon and thoroughly cleanse the clothes.

Mr. J. Adams, of Selby, exhibited a machine, in which the articles to be washed were placed in a perforated wooden barrel or octagonal vessel, rotating horizontally in an outer case. Above the case two wooden rollers are mounted, one over the other; and the clothes, when sufficiently washed, are passed between such rollers, so as to squeeze out the soap-suds, instead of wringing the clothes by hand. These rollers may be subsequently used for mangling the clothes.

Another rotary machine, exhibited by Mr. Pearson, of Leeds, consists of a tub or wooden vessel, in which the clothes are thrown; and the requisite agitation for washing or discharging the dirt is effected by means of an upright beater, which rotates in the tub in the same manner as the "dasher" of an upright rotary churn. This apparatus is also provided with a pair of rollers for wringing and mangling the clothes.

The next machines of the rotary class which we shall notice are those of Messrs. Manlove, Alliott, & Seyrig, of Lenton Works, Nottingham. In these machines the operations of washing and drying are effected by centrifugal force: that is, on the mangle-trundling principle. The utility of this construction of machines, both for washing and drying fabrics, is unquestionable; and, under slight modifications, they are extensively used for the refining of sugar. Each machine may be described as consisting simply of a drum, having its periphery formed of wires, and being fixed to a vertical shaft, which rotates in the centre of a cylindrical metal case. The goods to be washed are put into the drum, and water is supplied thereto through a hollow central shaft. On rapidly rotating the drum, the water is caused, by centrifugal force, to pass outwards through the goods, and through the wire periphery of the drum, into the outer case, from which it is conducted away. To dry washed, or wet goods, they are placed in the drum without access of water, and by the rapid rotation of the same the moisture in the clothes is discharged, — the time required for drying in no case exceeding five minutes. These machines are suitable for washing and rinsing dyed goods; but they are not applicable to the washing of thoroughly dirty clothes: they may, however, be used for rinsing the same after they have been washed by other means.

Mr. Robinson exhibited a machine for drying wet clothes, which acts upon the same principle as the above. The drum that receives the wet clothes is formed of round iron bars, with spaces between them, and mounted on a horizontal shaft. By means of a row of bars the drum is divided into two compartments, which receive the goods through a door formed in the drum-ends; and the whole is enclosed in a circular iron case, which is open below. The goods having been put into the drum, it is caused to revolve with great rapidity, and the moisture is expressed from the goods by centrifugal force, and escapes through the opening in the bottom of the case. See HYDRO-EXTRACTOR.

Another rotary washing machine is exhibited by Mr. Nunn. It consists of a large drum, which is mounted upon a horizontal shaft, within a closed vessel or case, and carries numerous small rollers all round its periphery, such rollers being capable of turning freely and independently of each other, and their axes being parallel to the axis of the drum. The case contains water or soap-suds, in which the drum is immersed to the extent of about one-fifth or one-sixth of its diameter; the clothes are kept in contact with the drum, as it revolves, by several endless tapes; and as the clothes successively arrive at the upper part of the drum, they are acted upon by five fluted rollers above it.

Mr. Nunn contributed another machine, which appears to be designed for rinsing and wringing only. Two fluted rollers, one above the other, are mounted in the upper part of a wooden vessel or trough; an endless band passes over the lower roller, for the purpose of conducting the clothes between the fluted rollers; and there is another endless band below, immersed in the water which the vessel contains, and passing over a roller at each end of the vessel, its apparent use being to receive the clothes as they fall from the first band, and bring them again to that end of the vessel where they were introduced.

Machines of the second class, viz. those wherein vibrating beaters are employed, were exhibited by Messrs. Fryer, Tasker, Marsden and Reid. In Mr. Fryer's machines, an upright board or beater, having vertical slots or openings in it, is caused to vibrate or swing to and fro in a segmental vessel (containing the clothes to be washed and a suitable quantity of soap-suds) and beat the clothes against the side of the vessel until they are thoroughly cleansed.

In Mr. Tasker's machine, a beater, with vertical slots or openings in it, vibrates in a trough or vessel having a series of projecting ribs at each side, corresponding with the openings in the beater.

The beater in Mr. Marsden's machine has a projecting rib affixed to it on each side, between the several slots or openings; and at each side of the segmental trough or vessel, in which the beater works, there is hinged a flap or false side, with numerous horizontal slots or openings in it.

The three last-mentioned machines are all provided with rollers for wringing and mangling the clothes.

Mr. Reid's machine consists of a large square box, the bottom of which takes the form of the segment described by a vibrating beater suspended in the box. The machine also contains a "wringer," which is a net formed into a bag, having an opening at the side for the introduction of the wet clothes; and at each end of the bag there is a screw bolt, with a nut upon it, by one of which the bag is to be secured to the side of the machine, and by the other it is connected to a crank, which, on being actuated, will twist the bag, and thereby express the water from the clothes. At the back of the machine several rollers are mounted one above the other, for the purpose of mangling the articles.

Mr. W. Macalpine, of Hammersmith, exhibited a machine of the third class, constructed with ascending and descending beaters. It consists of a cylindrical metal vessel, which is fixed upon an upright axis, and is caused to rotate by suitable wheel-work in connection with a steam engine. The vessel is made with perforated false bottom and sides, so as to form a hollow casing, into which steam may be admitted, and may thence pass through the perforations, and act upon the water and the fabrics to be washed. The process of agitating or washing the fabrics is effected by nine or ten upright beaters, arranged in a row across the interior of the vessel, and alternately elevated and permitted to fall upon the fabrics.

Messrs. Wilkinson, Stutterd, Baker, Moreton, and others, exhibited machines for performing the operation of mangling only; but as these, whatever their respective merits, cannot be said to be new applications of machinery for economizing labour, they do not properly come within our province.

From the above notice it will be seen that considerable attention has been given by machine makers to that most important branch of domestic economy—washing. There is not, perhaps, one of the machines above described, which would not as effectually cleanse all under-clothing as the most fastidious could desire; and yet we still suffer our clothes to be tortured by the rubbing and wringing of those merciless modern amazons who preside over soap-suds, and allow them to be transformed into lint and ribbons, without an attempt at removing the annoyance: indeed, so inveterate is prejudice, that the washerwoman may yet look for a long lease of her profession, as it luckily touches upon no established manufacture.

While on the subject of washing, we may direct attention to a machine, exhibited by Mr. C. Farrow, of Great Tower Street, for washing bottles. In this machine, a horizontal metal spindle, carrying a bottle brush at each end, is caused to revolve by being connected with a treadle. A bottle is pushed over each brush by the operator, who holds the bottles one in each hand, whilst by means of his foot he works the treadle and causes the rotation of the brushes.

Knife-cleaning.—Specimens of those very useful machines which have lately been introduced for cleaning knives and forks are to be found in the building, and demand some notice. Mr. Kent's machine consists of a box or case, containing a couple of wooden discs, fixed near to each other upon a horizontal iron rod or spindle, which passes through the case, and is caused to rotate by means of a winch-handle. Each disc is, for about three-fourths of the area of its inner face, covered with alternate rows of bristles and strips of leather; and the remaining fourth part is covered with bristles only. The knife-blades to be cleaned are introduced through openings in the case, between the rubbing surfaces of the discs; and rotatory motion being given to the discs by a winch handle, the knives are rapidly cleaned and polished.

The machines exhibited by Mr. Masters are constructed upon the same plan as the above; but the rubbing surface of each disc is formed of strips of buff leather, with only a narrow circle of bristles around the edge of each surface, to clean the shoulders of the knives; small brushes are fixed beneath the holes in the case, through which the blades of the knives are inserted, to prevent the exit of dust from the apparatus.

Mr. Price exhibited a machine for cleaning knives, and another for cleaning forks. The knife-cleaner consists of a horizontal drum, covered with pieces of leather or felt, and fixed within another drum or circular framing, lined with leather or felt. The knives are introduced through openings, in a moveable circular plate, at the front of the outer casing, and enter between the surfaces of the two drums. The plate is fixed upon a horizontal axis, which extends through the case, and is furnished at the back with a handle; by turning which the disc is caused to rotate and carry round the knives between the surfaces of the drums. The fork-cleaner consists of a box, with a long rectangular opening in the side; behind which two brushes are fixed, face to face. Between these brushes the prongs of the forks are introduced, and the handles are secured in a carrier, which is made to advance and recede alternately by means of a throw-crank, and thereby thrust the prongs into and draw them out of contact with the brushes. The carrier consists of two metal plates, the lower one carrying a cushion of vulcanized India rubber for the fork handles to rest upon, and the upper being lined

with leather; they are hinged together at one end, and are connected at the other, when the handles have been placed between them, by a thumb-screw.

Chopping-knife. — The same exhibitor also contributed a chopping-knife for the reduction of suet, &c., into small particles. It consists of three blades, fixed side by side, to the lower surface of a flat metal frame, which is hinged at one end to a fixed metal pillar or support, and at the other is provided with a handle, whereby the blades are alternately lifted and brought down upon the suet or other substance to be chopped, which is laid upon a circular wooden dish or chopping-block. Each time that the knife frame is raised, a hooked rod, suspended therefrom, catches into the teeth of a ratchet wheel, and turns it partly round; on the axis of this ratchet wheel is a small cog-wheel, which takes into the teeth of a circular rack or wheel, fixed to the underside of the chopping-block; and thus, at each ascent of the knife-frame, the block will be moved partly round, and made to present fresh portions of suet to the action of the descending knives. — *Newton's Journal*, xxxix. 132.

Envelope folding. — In the envelope folding machine of Messrs. De la Rue & Co. each piece of paper, previously cut by a fly press into the proper form for making an envelope, (and having the emblematical stamp or wafer upon it) is laid by the attendant on a square or rectangular metal frame or box, formed with a short projecting piece at each corner, to serve as guides to the paper, and furnished with a moveable bottom, which rests on helical springs. A presser at the end of a curved compound arm (which moves in a vertical plane), then descends, and presses the paper down into the box, — the bottom thereof yielding to the pressure; and thereby the four ends or flaps of the piece of paper are caused to fly up; the presser may be said to consist of a rectangular metal frame, the ends of which are attached to the outer part of the curved arm, and the sides thereof to the inner portion of the arm; so that the ends and sides of the presser can move independently of each other. The ends of the presser then rise, leaving the two sides of it still holding down the paper; two little lappet pieces next fold over the two side flaps of the envelope; and immediately a horizontal arm advances, carrying a V shaped piece charged with adhesive matter or cement (from a saturated endless band), and applies the same to the two flaps. A third lappet presses down the third flap of the envelope upon the two cemented flaps, and thereby causes it to adhere thereto; and then a pressing-piece, of the same size as the finished envelope, folds over the last flap and presses the whole flat. The final operation is to remove the envelope, and this is effected by a pair of metal fingers, with india rubber ends, which descend upon the envelope, and, moving sideways, draw the envelope off the bottom of the box (the pressing piece having moved away and the bottom of the box risen to the level of the platform of the machine) on to a slowly moving endless band, which gradually carries the finished envelopes away. A fresh piece of paper is laid upon the box or frame, and the above operations are repeated.

The working of this ingenious machine appeared to be one of the chief attractions of the Exhibition, but another, for the same object, invented by Mr. A. Remond, of Birmingham, and shown in operation by Messrs. Waterlow & Sons, of London Wall, was equally deserving attention. The distinguishing feature of this arrangement is the employment of atmospheric pressure to feed in the paper which is to form the envelope, and to deflect the flaps of the envelope into inclined positions, to facilitate the action of a plunger, which descends to complete the folding. The pieces of paper, cut to the proper form, are laid on a platform, which is furnished with a pin at each corner, to enter the notches in the pieces of paper, and retain them in the proper position, and such platform is caused alternately to rise and bring the upper piece of paper in contact with the instrument that feeds the folding part of the machine, and then to descend until a fresh piece is to be removed. The feeding instrument consists of a horizontal hollow arm, with two holes in the under side, and having a reciprocating movement. When it moves over the upper piece of paper on the platform, a partial vacuum is produced within it, by a suitable exhausting apparatus, and the paper is thereby caused to adhere to it at the holes in its under surface by the pressure of the atmosphere. The instrument carries the paper over a rectangular recess or box; and then, the vacuum within it being destroyed, it deposits the paper between four pins, fixed at the angles of the box, and returns for another piece of paper. As the paper lies on the top of the box, the flap, which will be undermost in the finished envelope, is pressed by a small bar or presser on to the upper edge of two angular feeders, communicating with a reservoir of cement or adhesive matter, and thereby becomes coated with cement; and, at the same time, the outermost or seal flap may be stamped with any required device, by dies, on the other side of the machine. A rectangular frame or plunger now descends and carries the paper down into the box; the plunger rises, leaving the flaps of the envelope upright; streams of air, issuing from a slot in each side of the box, then cause the flaps to incline inwards; and the folding is completed by the plunger again descending; the interior and under surface of such plunger being formed with projecting parts, suitable for causing the several flaps to fold in the proper order. The

bottom of the box (which is hinged) opens, and discharges the envelope down a shoot on to a table below; the feeding instrument then brings forward another piece of paper; and a repetition of the above movements takes place.

A machine for a somewhat similar purpose to the above was exhibited by Mr. J. Black, of Edinburgh. The object of this machine is to fold printed sheets of paper, and it is proportioned to fold them to the octavo size; but machines may be made, on the same principle, to suit books or pamphlets of other sizes. To fold sheets for an octavo book three movements are required, viz.: first, to fold the sheet to half size; secondly, to double it at right angles; and, thirdly, to double it again at right angles to the last fold. In the machine these movements are effected by three blades or knives, which are formed with serrated edges, to prevent the paper slipping. The blades are affixed, at one end, to separate shafts or spindles, which simultaneously perform part of a revolution in either direction alternately, and so cause the outer end of each blade to describe an arc of about the fourth part of a circle; and as the actions of the knives are simultaneous, the machine contains three sheets, in different states of progression at the same time. The sheet of paper is laid on a horizontal platform, in such a position that the first blade in descending will come across that part of the paper where the first fold is to be made,—draw the sheet through a slot or opening made in the platform, and carry it down into a narrow vertical passage or chamber; by which means it will be folded in half, and left in a vertical position. The second blade (which vibrates in a horizontal plane), then comes in contact with the central part of the doubled sheet, and folds it at that part, by drawing it into a narrow horizontal passage,—leaving such fold in a line at right angles to the vertical passage. The third blade (which vibrates in a vertical plane parallel to the first blade) draws the sheet down a vertical passage, so as to fold it again, and brings it to a pair of vertical delivering rollers, which pass it from the machine. Accuracy in laying the sheets upon the platform is insured by an arrangement, consisting of a short adjustable straight-edge, set parallel to the first blade, and of a projecting nob, set in the same parallel line. The attendant, who feeds the machine, takes hold of the sheet at the edge of the letter-press, and thus lays it on the platform in such a manner that his fingers come in contact with the straight-edge and nob,—whereby the central line of the sheet will be caused to lie exactly over the central slot in the platform; the position of the nob also indicates the point where the corner of the letter-press should be, in order that the subsequent folding in the opposite direction may be accurately performed. This is a very ingenious and efficient contrivance, and is well deserving the attention of book-binders.

Paging Books.—A self-acting machine for paging books and numbering documents was exhibited by Messrs. Waterlow & Sons, and shown in operation. As this class of machines has of late come into extensive use, owing to the protection which is afforded to the merchant and the tradesman by the consecutive paging of account and other manuscript books, it may be well to explain the general construction of the numbering apparatus, and its mode of operation, more especially as it forms an important adjunct to some machines which we shall hereafter have occasion to notice. The numbering apparatus consists of five discs, which are provided with raised figures on their periphery, running from 1, 2, 3, &c. to 0; and these figures serve (like letter press type) to print the numbers required. The discs are mounted at the outer end of a vibrating frame or arm on a common shaft, to which the first or units discs is permanently fixed; and the other four discs (viz. those for marking tens, hundreds, thousands, and tens of thousands,) are mounted loosely thereon, so that they need not, of necessity, move when the shaft is rotating; but they are severally caused to move in the following order:—the tens disc performs one tenth of a revolution for every revolution of the units disc; the hundreds disc makes one tenth of a revolution for every revolution of the tens disc; and so on. As the discs rise from the paper after every impression, the units disc is caused to perform one tenth of a revolution (in order that the next number printed may be a unit greater than the preceding one,) by a driving click taking into the teeth of a ratchet-wheel, fixed on the left hand end of the shaft. The movement of the other discs is effected, at intervals, by means of a spring-catch, affixed to the side of the units disc, and rotating therewith; which catch, each time that the units disc completes a revolution, is caused by a projection on the inner surface of the vibrating frame to project behind one of the raised figures on the tens disc, and carry it round one tenth of a revolution on the next movement of the units disc taking place; and then, the catch having passed away from the projection, no further increase in the number imprinted by the tens disc will be effected until the units disc has performed another revolution. Every time that the tens disc completes a revolution, the spring catch causes the hundreds disc to move forward one tenth of a revolution, and similar movements are imparted to the remaining discs at suitable times. The shaft is prevented from moving except when it is acted on by the driving click, by a spring detent, or pull entering the notches in the periphery of a

wheel fixed on the right hand end of the shaft; and thus the discs are held steady while numbering, and a clear and even impression of the figures is ensured. The leaves of the book to be paged or numbered are laid on the raised part of the table of the machine, covered with vulcanised india-rubber, and as each page is numbered it is turned over by the attendant, so as to present a fresh page on their next descent. As the discs ascend after numbering each page, an inking apparatus (consisting of three rollers, mounted in a swing frame, and revolving in contact with each other, so as to distribute the ink which is fed to the first roller evenly on to the third or inking roller,) descends and inks the figures which are to be brought into action, when the numbering apparatus next descends. By this means books or documents may be paged or marked with consecutive numbers; for printing duplicate sets of numbers, as for bankers' books, a simple and ingenious contrivance is adopted. This consists in the employment of an additional ratchet wheel, which is acted on by the driving click that moves the ratchet-wheel above mentioned, and is provided with a like number of teeth to that wheel. But the diameter of the additional ratchet wheel is increased to admit of the teeth being so formed that the driving click will be thereby held back from contact with every alternate tooth of the first mentioned ratchet wheel; and thus the arrangement of the numbering discs will remain unchanged, to give, on their next descent, a duplicate impression of the number previously printed; but, on the reascending of the numbering apparatus, the click will act on a tooth of both ratchet wheels, and move both forward one-tenth of a revolution; and, as the shaft accompanies the first ratchet wheel in its movements, the number will consequently be changed.

Messrs. Schlesinger & Co. also exhibited a paging machine, the capabilities of which are similar to the above, but somewhat differently obtained. The numbering discs in this instance are provided with ten teeth, with a raised figure on the end of each tooth; and they receive the change motion from cog wheels mounted below them on the same frame. At each descent of the frame a stationary spring catch or hook piece drives round the wheel one tooth, that gears into the teeth of the units disc, and thereby causes the units disc to bring forward a fresh figure. The toothed wheels are somewhat narrower than the numbering discs, but one tooth of each wheel is enlarged laterally to about double the size of the other teeth; so that at the completion of every revolution of the wheel the projecting tooth shall act upon a tooth of the next disc, and carry that disc forward one tenth of a revolution. By this means the requisite movements of the discs for effecting the regular progression of the numbers are produced; the first wheel driving its own disc, and communicating motion at intervals to the next disc, and the other wheels each receiving motion at intervals from the disc with which it is connected, and transmitting motion, at still greater intervals of time, to the next disc.

The machine is caused to print the figures in duplicate by drawing the spring-catch out of action at every alternate descent of the frame, and thereby preventing any change of the figures taking place until after the next impression.

The numbers may be increased two units at each impression, so as to print all even or all odd numbers, by bringing a second catch into action, which causes the unit disc to advance one step during the ascending movement of the frame, in addition to the advance during the descent of the same. — *Newton's Journal*, xxxviii. 430.

LABRADORITE; opaline or Labradore felspar is a beautiful mineral, with brilliant changing colours, blue, red, and green, &c. Spec. grav. 2.70 to 2.75. Scratches glass; affords no water by calcination; fusible at the blow-pipe into a frothy bead; soluble in muriatic acid; solution affords a copious precipitate with oxalate of ammonia. Cleavages of $93\frac{1}{2}^{\circ}$ and $86\frac{1}{2}^{\circ}$; one of which is brilliant and pearly. Its constituents are, silica, 55.75; alumina, 26.5; lime, 11; soda, 4; oxide of iron, 1.25; water, 0.5.

LABYRINTH, in Metallurgy, means a series of canals distributed in the sequel of a stamping-mill; through which canals a stream of water is transmitted for suspending, carrying off, and depositing, at different distances, the ground ores. See **METALLURGY**.

LAC, LAC-DYE. (*Laque*, Fr.; *Lack*, *Lackfarben*, Germ.) *Stick-lac* is produced by the puncture of a peculiar female insect, called *coccus lacca* or *ficus*, upon the branches of several plants; as the *ficus religiosa*, the *ficus indica*, the *rhamnus jujuba*, the *croton lacciferum*, and the *butea frondosa*, which grow in Siam, Assam, Pegu, Bengal, and Malabar. The twig becomes thereby incrustated with a reddish mammelated resin, having a crystalline-looking fracture.

The female lac insect is of the size of a louse; red, round, flat, with 12 abdominal circles, a bifurcated tail, antennæ, and 6 claws, half the length of the body. The male is twice the above size, and has 4 wings; there is one of them to 5000 females. In November or December the young brood makes its escape from the eggs, lying beneath the dead body of the mother; they crawl about a little way, and fasten themselves to the bark of the shrubs. About this period the branches often swarm to such a degree with this vermin, that they seem covered with a red dust; in this case, they are apt to dry up, by being exhausted of their juices. Many of these insects, however, become the

prey of others, or are carried off by the feet of birds, to which they attach themselves, and are transplanted to other trees. They soon produce small nipple-like incrustations upon the twigs, their bodies being apparently glued, by means of a transparent liquor, which goes on increasing to the end of March, so as to form a cellular texture. At this time, the animal resembles a small oval bag, without life, of the size of cochineal. At the commencement, a beautiful red liquor only is perceived, afterwards eggs make their appearance; and in October or November, when the red liquor gets exhausted, 20 or 30 young ones bore a hole through the back of their mother, and come forth. The empty cells remain upon the branches. These are composed of the milky juice of the plant, which serves as nourishment to the insects, and which is afterwards transformed or elaborated into the red colouring matter that is found mixed with the resin, but in greater quantity in the bodies of the insects, in their eggs, and still more copiously in the red liquor secreted for feeding the young. After the brood escapes, the cells contain much less colouring matter. On this account, the branches should be broken off before this happens, and dried in the sun. In the East Indies this operation is performed twice in the year; the first time in March, the second in October. The twigs encrusted with the radiated cellular substance constitute the *stick-lac* of commerce. It is of a red colour more or less deep, nearly transparent, and hard, with a brilliant conchoidal fracture. The stick-lac of Siam is the best; a piece of it presented to me by Mr. Rennie, of Fenchurch-street, having an incrustation fully one quarter of an inch thick all round the twig. The stick-lac of Assam ranks next; and, last, that of Bengal, in which the resinous coat is scanty, thin, and irregular. According to the analysis of Dr. John, stick-lac consists, in 120 parts, of

| | | | | | |
|---|---|---|---|---|-------|
| An odorous common resin | - | - | - | - | 80.00 |
| A resin insoluble in ether | - | - | - | - | 20.00 |
| Colouring matter analogous to that of cochineal | - | - | - | - | 4.50 |
| Bitter balsamic matter | - | - | - | - | 3.00 |
| Dun yellow extract | - | - | - | - | 0.50 |
| Acid of the stick-lac (laccic acid) | - | - | - | - | 0.75 |
| Fatty matter, like wax | - | - | - | - | 3.00 |
| Skins of the insects, and colouring matter | - | - | - | - | 2.50 |
| Salts | - | - | - | - | 1.25 |
| Earths | - | - | - | - | 0.75 |
| Loss | - | - | - | - | 4.75 |

120.00

According to Franke, the constituents of stick-lac are, resin, 65.7; substance of the lac, 28.3; colouring matter, 0.6.

Seed-lac.—When the resinous concretion is taken off the twigs, coarsely pounded, and triturated with water in a mortar, the greater part of the colouring matter is dissolved, and the granular portion which remains being dried in the sun, constitutes *seed-lac*. It contains of course less colouring matter than the stick-lac, and is much less soluble. John found in 100 parts of it, resin, 66.7; wax, 1.7; matter of the lac, 16.7; bitter balsamic matter, 2.5; colouring matter, 3.9; dun yellow extract, 0.4; envelopes of insects, 2.1; laccic acid, 0.0; salts of potash and lime, 1.0; earths, 6.6; loss, 4.2.

In India the *seed-lac* is put into oblong bags of cotton cloth, which are held over a charcoal fire by a man at each end, and, as soon as it begins to melt, the bag is twisted so as to strain the liquefied resin through its substance, and to make it drop upon smooth stems of the banyan tree (*musa paradisa*). In this way, the resin spreads into thin plates, and constitutes the substance known in commerce by the name of *shell-lac*.

The Pegu stick-lac, being very dark coloured, furnishes a shell-lac of a corresponding deep hue, and therefore of inferior value. The palest and finest shell-lac is brought from the northern Circar. It contains very little colouring matter. A stick-lac of an intermediate kind comes from the Mysore country, which yields a brilliant lac-dye and a good shell-lac.

Lac-dye is the watery infusion of the ground stick-lac, evaporated to dryness, and formed into cakes about two inches square and half an inch thick. Dr. John found it to consist of colouring matter, 50; resin, 25; and solid matter, composed of alumina, plaster, chalk, and sand, 22.

Dr. Macleod, of Madras, informs me that he prepared a very superior lac-dye from stick-lac, by digesting it in the cold in a slightly alkaline decoction of the dried leaves of the *Mimocylon tinctorium* (perhaps the *M. capitellatum*, from which the natives of Malabar and Ceylon obtain a saffron yellow dye). This solution being used along with a mordant consisting of a saturated solution of tin in muriatic acid, was found to dye woollen cloth of a very brilliant scarlet hue.

The cakes of *lac-dye* imported from India, stamped with peculiar marks to designate their different manufacturers, are now employed exclusively in England for dyeing scarlet cloth, and are found to yield an equally brilliant colour, and one less easily affected by perspiration than that produced by cochineal. When the lac-dye was first introduced, sulphuric acid was the solvent applied to the pulverized cakes, but as muriatic acid has been found to answer so much better, it has entirely supplanted it. A good solvent (No. 1.) for this dye-stuff may be prepared by dissolving 3 pounds of tin in 60 pounds of muriatic acid, of specific gravity 1.19. The proper mordant for the cloth is made by mixing 27 pounds of muriatic acid of sp. grav. 1.17, with $1\frac{1}{2}$ pounds of nitric acid of 1.19; putting this mixture into a salt-glazed stone bottle, and adding to it in small bits at a time, grain tin, till 4 pounds be dissolved. This solution (No. 2.) may be used within twelve hours after it is made, provided it has become cold and clear. For dyeing; three quarters of a pint of the solvent No. 1. is to be poured upon each pound of the pulverized lac-dye, and allowed to digest upon it for six hours. The cloth before being subjected to the dye bath, must be scoured in the mill with fullers' earth. To dye 100 pounds of pelisse cloth, a tin boiler of 300 gallons capacity should be filled nearly brimful with water, and a fire kindled under it. Whenever the temperature rises to 150° Fahr., a handful of bran, and half a pint of the solution of tin (No. 2.) are to be introduced. The froth, which rises as it approaches ebullition, must be skimmed off; and when the liquor boils, 10 $\frac{1}{2}$ pounds of lac-dye, previously mixed with 7 pints of the solvent No. 1., and 3 $\frac{1}{2}$ pounds of solution of tin No. 2., must be poured in. An instant afterwards, 10 $\frac{1}{2}$ pounds of tartar, and 4 pounds of ground sumach, both tied up in a linen bag, are to be suspended in the boiling bath for five minutes. The fire being now withdrawn, 20 gallons of cold water, with 10 $\frac{1}{2}$ pints of solution of tin being poured into the bath, the cloth is to be immersed in it, moved about rapidly during ten minutes; the fire is to be then re-kindled, and the cloth winced more slowly through the bath, which must be made to boil as quickly as possible, and maintained at that pitch for an hour. The cloth is to be next washed in the river; and lastly with water only, in the fulling mill. The above proportions of the ingredients produce a brilliant scarlet tint, with a slightly purple cast. If a more orange hue be wanted, white Florence argal may be used, instead of tartar, and some more sumach. Lac-dye may be substituted for cochineal in the orange-scarlets; but for the more delicate pink shades, it does not answer so well, as the lustre is apt to be impaired by the large quantity of acid necessary to dissolve the colouring matter of the lac.

Shell-lac, by Mr. Hatchett's analysis, consists of resin, 90.5; colouring matter, 0.5; wax, 4.0; gluten, 2.8; loss, 1.8; in 100 parts.

The resin may be obtained pure by treating shell-lac with cold alcohol, and filtering the solution in order to separate a yellow gray pulverulent matter. When the alcohol is again distilled off, a brown, translucent, hard, and brittle resin, of specific gravity 1.139, remains. It melts into a viscid mass with heat, and diffuses an aromatic odour. Anhydrous alcohol dissolves it in all proportions. According to John, it consists of two resins, one of which dissolves readily in alcohol, ether, the volatile and fat oils; while the other is little soluble in cold alcohol, and is insoluble in ether and the volatile oils. Unverdorben, however, has detected no less than four different resins, and some other substances in shell-lac. Shell-lac dissolves with ease in dilute muriatic and acetic acids; but not in concentrated sulphuric acid. The resin of shell-lac has a great tendency to combine with salifiable bases; as with caustic potash, which it deprives of its alkaline taste.

This solution, which is of a dark red colour, dries into a brilliant, transparent reddish brown mass; which may be re-dissolved in both water and alcohol. By passing chlorine in excess through the dark-coloured alkaline solution, the lac-resin is precipitated in a colourless state. When this precipitate is washed and dried, it forms, with alcohol, an excellent pale-yellow varnish, especially with the addition of a little turpentine and mastix.

With the aid of heat, shell-lac dissolves readily in a solution of borax.

The substances which Unverdorben found in shell-lac are the following:

1. A resin, soluble in alcohol and ether;
2. A resin, soluble in alcohol, insoluble in ether;
3. A resinous body, little soluble in cold alcohol;
4. A crystallizable resin;
5. A resin, soluble in alcohol and ether, but insoluble in petroleum, and uncrystallizable.
6. The unsaponified fat of the *coccus* insect, as well as oleic and margaric acids.
7. Wax.
8. The *laccins* of Dr. John.
9. An extractive colouring matter.

STATISTICAL TABLE of LAC-DYE and LAC-LAKE, per favour of James Wilkinson, Esq.,
of Leadenhall-street.

| | Import. | Export. | Home Consumption. | Prices. | | Stocks. | | |
|------|-------------|-------------|-------------------|-----------|-----------|---------------|---|--------|
| | <i>Lbs.</i> | <i>Lbs.</i> | <i>Lbs.</i> | <i>s.</i> | <i>d.</i> | | | |
| 1802 | 253 | none | none | | | | | |
| 1803 | 1,735 | - | acct. burned | | | | | |
| 1804 | 531 | | | | | | | |
| 1805 | 1,987 | | | | | | | |
| 1806 | none | | | | | | | |
| 1807 | 25,350 | | | | | | | |
| 1808 | 5,731 | | | | | | | |
| 1809 | 40,632 | | | | | | | |
| 1810 | 235,154 | | | | | | | |
| 1811 | 378,325 | | | | | | | |
| 1812 | 198,250 | | | | | | | |
| 1813 | 289,654 | | | | | | | |
| 1814 | 278,899 | 5,071 | 133,935 | | | | | |
| 1815 | 598,592 | 8,441 | 137,915 | | | | | |
| 1816 | 269,373 | 27,412 | 162,894 | | | | | |
| 1817 | 384,909 | 23,091 | 234,763 | | | | | |
| 1818 | 242,572 | 32,079 | 323,169 | | | | | |
| 1819 | 179,511 | 21,707 | 207,063 | | | | | |
| 1820 | 441,486 | 49,519 | 912,514 | | | | | |
| 1821 | 641,755 | 91,925 | 322,837 | | | | | |
| 1822 | 872,967 | 29,578 | 349,351 | | | | | |
| 1823 | 534,220 | 13,050 | 414,714 | | | | | |
| 1824 | 604,269 | 53,843 | 483,339 | | | | | |
| 1825 | 541,443 | 61,908 | 385,734 | | | | | |
| 1826 | 760,729 | 68,603 | 395,609 | | | <i>chests</i> | | |
| 1827 | 756,315 | 76,875 | 448,270 | 1 | 9 | 4 | 0 | 11,538 |
| 1828 | 512,874 | 54,999 | 397,867 | 1 | 3 | 3 | 9 | 11,085 |
| 1829 | 475,632 | 39,344 | 433,851 | 1 | 3 | 3 | 6 | 11,976 |
| 1830 | 534,241 | 78,099 | 548,865 | 0 | 9 | 3 | 3 | 11,834 |
| 1831 | 913,562 | 175,717 | 597,568 | 0 | 4 | 2 | 6 | 12,559 |
| 1832 | 378,843 | 69,842 | 594,155 | 0 | 4 | 2 | 3 | 11,420 |
| 1833 | 326,894 | 66,447 | 426,460 | 0 | 9 | 2 | 4 | 11,457 |
| 1834 | 708,959 | 89,229 | 398,832 | 0 | 11 | 2 | 4 | 11,928 |
| 1835 | 528,564 | 203,840 | 573,288 | 0 | 11 | 3 | 0 | 10,454 |
| 1836 | 642,436 | 200,975 | 642,615 | 1 | 0 | 4 | 0 | 9,492 |
| 1837 | 1,011,674 | 133,959 | 427,890 | 1 | 0 | 3 | 9 | 8,780 |

The Stock includes 2,200 chests of Lac-lake.

LANDINGS, DELIVERIES, AND STOCKS OF LAC DYES.

| Year. | Landed. | Delivered. | Stock 1st January. |
|-------------------|------------|------------|--------------------|
| In December 1851 | 464 chests | 192 chests | — chests |
| 1850 | 564 | 308 | — |
| In 12 months 1851 | 7152 | 4741 | 7777 |
| 1850 | 5860 | 4063 | 5356 |
| 1849 | 3954 | 4126 | 3569 |
| 1848 | 1577 | 3020 | 4421 |

Layton, Hulbert and Co.'s Circular, 7th Jan. 1852.

The market prices on 8th Jan. 1852 were from 3d. to 2s. 4d. per lb.

LACCIC ACID crystallizes, has a wine-yellow colour, a sour taste, is soluble in water, alcohol, and ether. It was extracted from stick-lac by Dr. John.

LACCINE is the portion of shell-lac which is insoluble in boiling alcohol. It is brown, brittle, translucent, consisting of agglomerated pellicles, more like a resin than any thing else. It is insoluble in ether and oils. It has not been applied to any use.

LACE BOBBINET. Hitherto the threads of silk, flax, or cotton, used as the chain or warp in the manufacture of lace or net, have been warped, or ranged side by side, and in this state wound upon a cylinder, which being mounted upon an axle or shaft, delivers the warp threads as each mesh of the net is formed. By the patented arrangement of Mr. W. E. Newton, whatever may be the difference in the consumption of the several threads to produce the fabric, in comparison with other portions of the warp, the cylinder will always deliver the same quantity in length of each thread. This

gives rise to great inconvenience. According to the present invention, for every thread a bobbin is provided for regulating its tension; and thus each separate thread or number of threads may, without inconvenience, furnish a greater or less length of warp as may be required. See the details, with figures, in *Newton's London Journal*, xxxv. 391.

LACE MANUFACTURE. The pillow-made, or bone-lace, which formerly gave occupation to multitudes of women in their own houses, has, in the progress of mechanical invention, been nearly superseded by the bobbin-net lace, manufactured at first by hand-machines, as stockings are knit upon frames, but recently by the power of water or steam. This elegant texture possesses all the strength and regularity of the old Buckingham lace, and is far superior in these respects to the point-net and warp lace, which had preceded, and in some measure paved the way for it. Bobbin-net may be said to surpass every other branch of human industry in the complex ingenuity of its machinery; one of Fisher's spotting frames being as much beyond the most curious chronometer in multiplicity of mechanical device, as that is beyond a common roasting-jack.

The threads in bobbin-net lace form, by their intertwisting and decussation, regular hexagonal holes or meshes, of which the two opposite sides, the upper and under, are directed along the breadth of the piece, or at right angles to the selvage or border.

833

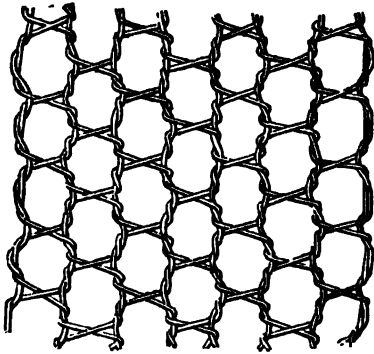
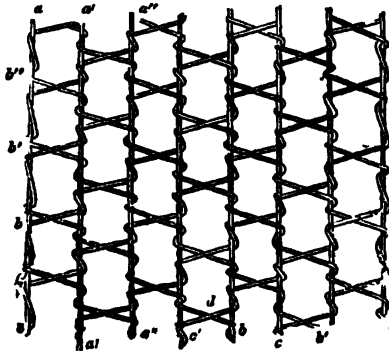


Fig. 833. shows how, by the crossing and twisting of the threads, the regular six-sided mesh is produced, and that the texture results from the union of three separate sets of threads, of which one set proceeds downwards in serpentine lines, a second set proceeds from the left to the right, and a third from the right to the left, both in slanting directions. These oblique threads twist themselves round the vertical ones, and also cross each other betwixt them, in a peculiar manner, which may be readily understood by examining the representation. In comparing bobbin-net with a common web, the perpendicular threads in the figure, which are parallel to the border, may be regarded as the warp, and the two sets of slanting threads as the weft.

These warp threads are extended up and down, in the original mounting of the piece between a top and bottom horizontal roller or beam, of which one is called the warp beam, and the other the lace beam, because the warp and finished lace are wound upon them respectively. These straight warp threads receive their contortion from the tension of the weft threads twisted obliquely round them alternately to the right and the left hand. Were the warp threads so tightly drawn that they became inflexible, like fiddle-strings, then the lace would assume the appearance shown in *fig. 834*; and although this condition does not really exist, it may serve to illustrate the structure of the web. The warp threads stand in the positions *a a*, *a' a'*, and *a'' a''*; the one half of the weft proceeds in the direction *b b*, *b' b'*, and *b'' b''*; and the second crosses the

834

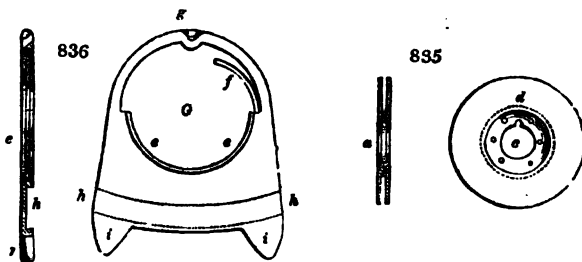


first by running in the direction *c c*, or *c' c'*, towards the opposite side of the fabric. If we pursue the path of a weft thread, we find it goes on till it reaches the outermost or last warp thread, which it twists about; not once, as with the others, but twice; and then returning towards the other border, proceeds in a reverse direction. It is by this double twist, and by the return of the weft threads, that the selvage is made.

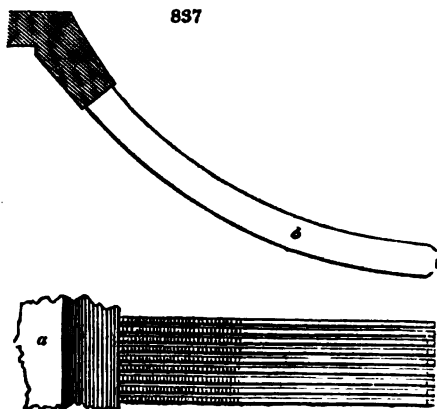
The ordinary material of bobbin-net is two cotton yarns, of from No. 180. to No. 250. twisted into one thread; but sometimes strongly twisted single yarn has been used. The beauty of the fabric depends upon the quality of the material, as well as the regularity and smallness of the meshes. The number of warp threads in a yard in

breadth is from 600 to 900; which is equivalent to from 20 to 30 in an inch. The size of the holes cannot be exactly inferred from that circumstance, as it depends partly upon the oblique traction of the threads. The breadth of the pieces of bobbin-net varies from edgings of a quarter of an inch to webs 19 or even 20 quarters, that is, 2 yards wide.

Bobbin-net lace is manufactured by means of very costly and complicated machines, called *frames*. The limits of this Dictionary will admit of an explanation of no more than the general principles of the manufacture. The threads for crossing and twisting round the warp, being previously gassed, that is, freed from loose fibres by singeing with gas, are wound round small pulleys, called bobbins, which are, with this view, deeply grooved in their periphery. *Figs. 835, 836.* exhibit the bobbin alone, and with its carriage.



In the section of the bobbin *a*, *fig. 835.*, the deep groove is shown in which the thread is wound. The bobbin consists of two thin discs of brass, cut out in a stamp-press, in the middle of each of which there is a hollow space *c*. These discs are riveted together leaving an interval between their edge all round, in which the thread is coiled. The round hole in the centre, with the little notch at top, serves for spitting them upon a feathered rod, in order to be filled with thread by the rotation of that rod in a species of reel, called the bobbin-filling machine. Each of these bobbins (about double the size of the figure) is inserted into the vacant space *o* of the carriage, *fig. 836.* This is a small iron frame (also double the size of the figure), which, at *e e*, embraces the grooved border of the bobbin, and by the pressure of the spring at *f*, prevents it from falling out. This spring serves likewise to apply sufficient friction to the bobbin, so as to prevent it from giving off its thread at *g* by its rotation, unless a certain small force of traction be employed upon the thread. The curvilinear groove *h h*, sunk in each face or side of the carriage, has the depth shown in the section at *h*. The groove corresponds to the interval between the teeth of the comb, or bars of the bolt, in which each carriage is placed, and has its movement. A portion of that bolt or comb is shown at *a*, *fig. 837.* in plan, and one bar of a circular bolt machine at *b*, in section. If we suppose two such combs or bolts placed with the ends of the teeth opposite each other, but a little apart, to let the warp threads be stretched, in one vertical plane, between their ends or tips, we shall have an idea of the skeleton of a bobbin-net machine. One of these two combs, in the double bolt machine, has an occasional lateral movement called *shogging*, equal to the interval of one tooth or bolt, by which, after it has received the bobbins,

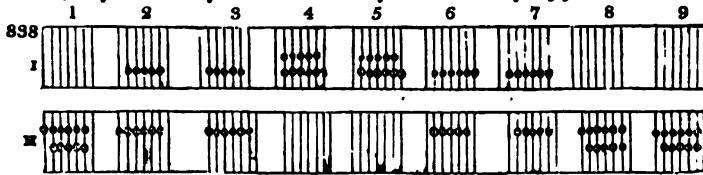


with their carriages, into its teeth, it can shift that interval to the one side, and thereby get into a position to return the bobbins, with their carriages, into the next series of interstices or gates, in the other bolt. By this means the whole series of carriages receives successive side steps to the right in one bolt, and to the left in the other, so as to perform a species of countermarch, in the course of which they are made to cross and twist round about the vertical warp threads, and thus to form the meshes of the net.

The number of movements required to form a row of meshes in the double tier machine, that is, in a frame with 2 combs or bars, and 2 rows of bobbins, is six; that is, the whole of the carriages (with

their bobbins) pass from one bar or comb to the other six times, during which passages the different divisions of bobbin and warp threads change their relative positions 12 times.

This interchange or traversing of the carriages with their bobbins, which is the most difficult thing to explain, but at the same time the most essential principle of the lace-machine, may be tolerably well understood by a careful study of *fig. 838*. in which the



simple line | represents the bolts or teeth, the sign ϕ the back line of carriages, and the sign ϕ the front line of carriages. π is the front comb or bolt bar, and ι the back bolt bar. The former remains always fixed or stationary, to receive the carriages as they may be presented to it by the shogging of the latter. There must be always one odd carriage at the end; the rest being in pairs.

No. 1. represents the carriages in the front comb or bar, the odd carriage being at the left end. The back line of carriages is first moved on to the back bar ι , the odd carriage, as seen in No. 1., having been left behind, there being no carriage opposite to drive it over to the other comb or bar. The carriages then stand as in No. 2. The bar ι now shifts to the left, as shown in No. 3.; the front carriages then go over into the back bar or comb, as is represented by No. 4. The bar ι now shifts to the right, and gives the position No. 5. The front carriages are then driven over to the front bar, and leave the odd carriage on the back bar at the right end, for the same reason as before described, and the carriages stand as shown in No. 6. The bar ι next shifts to the left, and the carriages stand as in No. 7. (the odd carriage being thereby on the back bar to the left.) The back carriages now come over to the front bar, and stand as in No. 8. The back bar or comb ι shifts to the right as seen in No. 9., which completes the traverse. The whole carriages with their bobbins have now changed their position, as will be seen by comparing No. 9. with No. 1. The odd carriage, No. 1., ϕ has advanced one step to the right, and has become one of the front tier; one of the back tier or line ϕ has advanced one step to the left, and has become the odd carriage; and one of the front ones ϕ has gone over to the back line. The bobbins and carriages throughout the whole width of the machine have thus crossed each other's course, and completed the mesh of net.

The carriages with their bobbins are driven a certain way from the one comb to the other, by the pressure of two long bars (one for each) placed above the level of the comb, until they come into such a position that their projecting heels or catches *i i*, *fig. 836.*, are moved off by two other long flat bars below, called the locker plates, and thereby carried completely over the interval between the two combs.

There are six different systems of bobbin-net machines. 1. Heathcoate's patent machine. 2. Brown's traverse warp. 3. Morley's straight bolt. 4. Clarke's pusher principle, single tier. 5. Leaver's machine, single tier. 6. Morley's circular bolt. All the others are mere variations in the construction of some of their parts. It is a remarkable fact, highly honourable to the mechanical judgment of the late Mr. Morley of Derby, that no machines except those upon his circular bolt principle have been found capable of working successfully by mechanical power.

The circular bolt machine (comb with curved teeth) was used by Mr. Morley, for making narrow breadths or edgings of lace immediately after its first invention, and it has been regularly used by the trade for that purpose ever since, in consequence of the inventor having declined to secure the monopoly of it to himself by patent. A* that time the locker bars for driving across the carriages had only one plate or blade. A machine so mounted is now called "the single locker circular bolt." In the year 1824, Mr. Morley added another plate to each of the locker bars, which was a great improvement on the machines for making plain net, but an obstruction to the making of narrow breadths upon them. This machine is now distinguished from the former by the term "double locker."*

A rack of lace, is a certain length of work counted perpendicularly, and contains 240 meshes or holes. Well-made lace has the meshes a little elongated in the direction of the selvage.

* By reading the above brief account of Bobbin-net, in connexion with the more detailed description of it in my *COTTON MANUFACTURE OF GREAT BRITAIN*, a tolerably clear conception of the nature of this intricate manufacture may be obtained.

The term gauge, in the lace manufacture, means the number of gates, slits, or interstices, in one inch of the bolt-bar or comb; and corresponds therefore to the number of bobbins in an inch length of the double tier. Thus, when we say "gauge nine points," we mean that there are nine gates with nine bobbins in one inch of the comb or bolt-bar. Each of such bobbins with its carriage is therefore no more than one ninth of an inch thick. The common proportion or gauge up and down the machine is 16 holes in the inch for ten bobbins transversely. Circular bolt double tier machines can turn off by steam power fully 360 racks each day of 18 hours, with a relay of superintendents.

The number of new mechanical contrivances to which this branch of manufacture has given rise, is altogether unparalleled in any other department of the arts. Since Mr. Heathcote's first successful patent, in 1809, a great many other patents have been granted for making lace. In the year 1811, Mr. Morley, then of Nottingham, invented his straight bolt frame, more simple in construction, better combined, and more easy in its movements, than the preceding machines; but the modest inventor did not secure it, as he might have done, by patent. The pusher machine was invented in the same year, by Samuel Mart and James Clark, also of Nottingham. The following year is remarkable in the history of the lace trade, for the invention of the circular bolt machine, by Mr. Morley—a mechanism possessing all the advantages of his straight bolt machine, without its disadvantages.

Nearly at the same time Mr. John Leaver brought forward the lever machine, conjointly with one Turton, both of New Radford, near Nottingham. About the year 1817, or 1818, Mr. Heathcote applied the rotatory movement to the circular bolt machine, and mounted a manufactory on that plan, by mechanical power, at Tiverton, after he and his partner, Mr. Boden, had been driven from Loughborough, in 1816, by the atrocious violence of the frame-destroying Luddites.

Such has been the progress of improvement and economy in this manufacture, that the cost of labour in making a rack, which was, twenty years ago, 3s. 6d., or 42 pence, is now not more than one penny. The prices of this beautiful fabric have fallen in an equally remarkable manner. At the former period, a 24 rack piece, five quarters broad, fetched 17l. sterling, in the wholesale market; the same is now sold for 7s. The consequence is, that in lace decoration, the maid servant may now be more sumptuously arrayed than her mistress could afford to be twenty years ago.

LACQUER, is a varnish, consisting chiefly of a solution of pale-shell-lac in alcohol, tinged with saffron, annatto, or other colouring matters. See VARNISH.

LACTIC ACID. (*Acide Lactique*, Fr.; *Milchsäure*, Germ.) This acid was discovered by Scheele in buttermilk, where it exists most abundantly; but it is present also in fresh milk in small quantity, and communicates to it the property of reddening litmus. Lactic acid may be detected in all the fluids of the animal body; either free or saturated with alkaline matter.

Scheele obtained this acid by evaporating the sour whey of clotted milk to an eighth part of its bulk, saturating this remainder with slaked lime, in order to throw down the subphosphate of lime held in solution, filtering the liquor, diluting it with thrice its weight of water, and precipitating the lime circumspcctly, by the gradual addition of oxalic acid. He next filtered, evaporated to dryness on a water bath, and digested the residuum in strong alcohol, which dissolved the lactic acid, and left the sugar of milk. On evaporating off the alcohol, the acid was obtained. As thus procured, it requires to be purified by saturation with carbonate of lead (pure white lead), and precipitating the solution of this lactate with sulphate of zinc, not added in excess. Sulphate of lead falls, and the supernatant lactate of zinc being evaporated affords crystals, at first brown, but which become colourless on being dissolved and re-crystallized twice or thrice. If the sulphuric acid of the dissolved salt be thrown down by water of baryta, the liquid when filtered and evaporated yields a pure lactic acid, of a syrupy consistence, colourless and void of smell. It has a pungent acid taste, which it loses almost entirely when moderately diluted with water. It does not crystallize. Its salts, with the exception of those of magnesia and zinc, have a gummy appearance, and are very soluble in alcohol, unless they hold an excess of base. Lactic acid consists of 44.92 carbon; 6.55 hydrogen; 48.53 oxygen. It contains 9.92 per cent. of water. It has not hitherto been applied to any use in the arts, except by the Dutch in their old process of bleaching linen with sour milk. See FERMENTATION.

New method of preparing.—The following process for procuring lactic acid and the lactates is so simple, as to merit a preference over all others heretofore proposed; it is as follows:—"Take 3 or 4 litres (litre=1.76 pint) of milk, into which you pour a solution of from 200 to 300 grammes (gramme=15.438 gra. Troy.) of sugar of milk; the liquor is exposed to the air in an open vessel for some days, at a temperature of from 59° to 68° Fahr. It will then be found to have become very acid, and is to be saturated with bicarbonate of soda. After the lapse of 24 or

36 hours it becomes again acid, and must be saturated anew, repeating the process, until the whole of the sugar of milk has been converted into lactic acid. When it is considered that the transformation is complete, the milk must be boiled to coagulate the caseum; the liquid is next to be filtered and evaporated to the consistence of syrup, taking care that the temperature be moderate. The product of evaporation is taken up by alcohol at 38°, which dissolves the lactate of soda. Into this alcoholic solution an adequate quantity of sulphuric acid is to be poured; the resulting sulphate of soda falls down, and the liquor by filtration and evaporation affords lactic acid almost pure. To obtain it in a state of great purity, it may be saturated with chalk; the lactate of lime crystallises directly in white granules, whence we can separate the lactic acid by the ordinary means.

It is evident the lactic acid may be saturated with any other base, and afford expeditiously crystallized lactates.

LACTOMETER is the name of an instrument for estimating the quality of milk, called also a *Galactometer*. The most convenient form of apparatus would be a series of glass tubes each about 1 inch in diameter, and 12 inches long, graduated through a space of 10 inches, to tenths of an inch, having a stop-cock at the bottom, and suspended upright in a frame. The average milk of the cow being poured in to the height of 10 inches, as soon as the cream has all separated at top, the thickness of its body may be measured by the scale; and then the skim-milk may be run off below into a hydrometer glass, in order to determine its density, or relative richness in caseous matter, and dilution with water.

LAKES. Under this title are comprised all those colours which consist of a vegetable dye, combined by precipitation with a white earthy basis, which is usually alumina. The general method of preparation is to add to the coloured infusion a solution of common alum, or rather a solution of alum saturated with potash, especially when the infusion has been made with the aid of acids. At first only a slight precipitate falls, consisting of alumina and the colouring matter; but on adding potash, a copious precipitation ensues, of the alumina associated with the dye. When the dyes are not injured, but are rather brightened by alkalis, the above process is reversed; a decoction of the dye-stuff is made with an alkaline liquor, and when it is filtered, a solution of alum is poured into it. The third method is practicable only with substances having a great affinity for subsulphate of alumina; it consists in agitating recently precipitated alumina with the decoction of the dye.

Yellow lakes are made with a decoction of Persian or French berries, to which some potash or soda is added; into the mixture a solution of alum is to be poured as long as any precipitate falls. The precipitate must be filtered, washed, and formed into cakes, and dried. A lake may be made in the same way with quercitron, taking the precaution to purify the decoction of the dye-stuff with buttermilk or glue. After filtering the lake it may be brightened with a solution of tin. Annatto lake is formed by dissolving the dye-stuff in a weak alkaline lye, and adding alum water to the solution. Solution of tin gives this lake a lemon yellow cast; acids a reddish tint.

Red lakes.—The finest of these is *carmine*.

This beautiful pigment was accidentally discovered by a Franciscan monk at Pisa. He formed an extract of cochineal with salt of tartar, in order to employ it as a medicine, and obtained, on the addition of an acid to it, a fine red precipitate. Homberg published a process for preparing it, in 1656. Carmine is the colouring matter of cochineal, prepared by precipitation from a decoction of the drug. Its composition varies according to the mode of making it. The ordinary carmine is prepared with alum, and consists of *carminium* (see COCHINEAL), a little animal matter, alumina, and sulphuric acid. See CARMINE.

Carminated lake, called lake of Florence, Paris, or Vienna. For making this pigment, the liquor is usually employed which is decanted from the carmine process. Into this, newly precipitated alumina is put; the mixture is stirred, and heated a little, but not too much. Whenever the alumina has absorbed the colour, the mixture is allowed to settle, and the liquor is drawn off.

Sometimes alum is dissolved in the decoction of cochineal, and potash is then added, to throw down the alumina in combination with the colouring matter; but in this way an indifferent pigment is obtained. Occasionally, solution of tin is added, to brighten the dye.

A lake may be obtained from kermes, in the same way as from cochineal; but now it is seldom had recourse to.

Brazil-wood lakes.—Brazil wood is to be boiled in a proper quantity of water for 15 minutes; then, alum and solution of tin being added, the liquor is to be filtered, and a solution of potash poured in as long as it occasions a precipitate. This is separated by the filter, washed in pure water, mixed with a little gum water, and made into cakes. Or, the Brazil wood may be boiled along with a little vinegar, the decoction filtered,

alum and salt of tin added, and then potash-lye poured in to precipitate the lake. For 1 pound of Brazil wood, 30 to 40 pounds of water, and from $1\frac{1}{2}$ to 2 pounds of alum, may be taken, in producing a deep red lake; or, the same proportions with half a pound of solution of tin. If the potash be added in excess, the tint will become violet. Cream of tartar occasions a brownish cast.

Madder lake.— A fine lake may be obtained from madder, by washing it in cold water as long as it gives out colour; then sprinkling some solution of tin over it, and setting it aside for some days. A gentle heat may also be applied. The red liquor must be then separated by the filter, and decomposed by the addition of carbonate of soda, when a fine red precipitate will be obtained. Or, the reddish-brown colouring matter of a decoction of madder may be first separated by acetate of lead, and then the rose-red colour with alum. Or, madder tied up in a bag is boiled in water; to the decoction alum is added, and then potash. The precipitate should be washed with boiling water, till it ceases to tinge it yellow; and it is then to be dried.

The following process merits a preference.

Diffuse 2 pounds of ground madder in 4 quarts of water, and after a maceration of 10 minutes, strain and squeeze the grounds in a press. Repeat this maceration, &c. twice upon the same portion of madder. It will now have a fine rose colour. It must then be mixed with 5 or 6 pounds of water and half a pound of bruised alum, and heated upon a water bath for 3 or 4 hours, with the addition of water, as it evaporates, after which the whole must be thrown upon a filter cloth. The liquor which passes is to be filtered through paper, and then precipitated by carbonate of potash. If the potash be added in three successive doses, three different lakes will be obtained, of successively diminishing beauty. The precipitates must be washed till the water comes off colourless.

Blue lakes are hardly ever prepared, as indigo, prussian blue, cobalt blue, and ultramarine, answer every purpose of blue pigments.

Green lakes are made by a mixture of yellow lakes with blue pigments; but chrome yellows mixed with blues produce almost all the requisite shades of green.

LAMINABLE is said of a metal which may be extended by passing between steel or hardened (chilled) cast-iron rollers.

For a description of metal rolling presses, see IRON and METAL; and

For a table of the relative laminability of metals, see DUCTILITY.

LAMIUM ALBUM, or the dead nettle, is said by Leuchs to afford in its leaves a greenish-yellow dye. The *L. purpureum* dyes a reddish-gray with salt of tin, and a greenish tint with iron liquor.

LAMPS differ so much in principle, form, and construction, as to render their description impossible, as a general subject of manufacture. In fact, the operations of the lampist, like those of the blacksmith, cabinet-maker, cooper, copper-smith, tinman, turner, &c., belong to a treatise upon handicraft trades. I shall here, however, introduce a tabular view of the relative light and economy of the lamps most generally known.

| Kind of Lamps. | Intensity of Light during | | | | | | Mean of 7 hours. | Consumption per hour in grammes. | Light from 100 parts of oil. |
|--|---------------------------|---------|---------|---------|---------|---------|------------------|----------------------------------|------------------------------|
| | 1 hour | 2 hours | 3 hours | 4 hours | 5 hours | 6 hours | | | |
| 1. Mechanical lamp of Carcel - | - | - | - | - | - | - | 100 | 42 | 238 |
| 2. Fountain lamp, and a chimney with flat wick - | 100 | 98 | 98 | 97 | 96 | 96 | 125 | 11 | 113 |
| 3. Dome argand - | 103 | 90 | 72 | 61 | 42 | 34 | 31 | 26.714 | 116 |
| 4. Sinumbra lamp - | 102 | 95 | 83 | 81 | 78 | 66 | 56 | 37.145 | 150 |
| 5. Do. with fountain above - | 100 | 90 | 70 | 52 | 41 | 32 | 85 | 43 | 197 |
| 6. Do. with another beak - | 100 | 97 | 95 | 92 | 89 | 86 | 41 | 18 | 227 |
| 7. Girard's hydrostatic lamp - | 101 | 96 | 84 | 81 | 76 | 70 | 63.66 | 34.714 | 182 |
| 8. Thilorier's or Parker's ditto lamp - | 106 | 103 | 100 | 94 | 92 | 90 | 107.66 | 51.143 | 215 |

In the above table, for the purpose of comparing the successive degrees of intensity, 100 represents the mean intensity of light during the first hour. The quantity of oil consumed per hour is given in grammes, of $15\frac{1}{2}$ grains each. The last column expresses the quantity of light produced with a like consumption of oil, which was in all cases 100 grammes. See CANDLES.

The following table of M. Pecllet is perhaps more instructive : —

| Nature of the Light. | Intensity. | Consumption per hour in grammes. | Cost. | | Fat producing the same light. | Cost per hour. |
|--|------------|----------------------------------|-------------------------|----------------------|-------------------------------|----------------------|
| | | | per kilogr. | of light per hour. | | |
| 1. Mechanical lamp - | 100 | 42 | <i>Francia.</i> 1'40 | <i>Cents.</i> 5'8 | <i>Grammes.</i> 43 | <i>Cents.</i> 5'8 |
| 2. Flat-wick mechanical do. - | 12'05 | 11 | 1'40 | 1'5 | 88 | 12'3 |
| 3. Hemispherical dome lamp - | 31'0 | 26'714 | 1'40 | 3'7 | 86'16 | 12'0 |
| 4. Sinumbra lamp - | 85 | 43 | 1'40 | 6'0 | 50'58 | 7'0 |
| 5. Do. with a lateral fountain or vase - | 41 | 18 | 1'40 | 2'5 | 43'90 | 6'1 |
| 6. Do. with a fountain above - | 90 | 43 | 1'40 | 6'0 | 47'77 | 6'6 |
| 7. Girard's hydrostatic lamp - | 63'66 | 34'71 | 1'40 | 4'8 | 54'52 | 7'6 |
| 8. Thilorier's or Parker's do. - | 107'66 | 51'143 | 1'40 | 7'1 | 47'5 | 6'6 |
| 9. Candle, 6 in lb. - | 10'66 | 8'51 | 1'40 | 1'2 | 70'35 | 9'8 |
| 10. Do. 8 in do. - | 8'74 | 7'51 | 1'40 | 1'0 | 85'92 | 12'0 |
| 11. Do. 6 with smaller wick - | 7'50 | 7'42 | 2'40 | 1'7 | 98'93 | 23'7 |
| 12. Wax candle, 5 in lb. - | 13'61 | 8'71 | 7'60 | 5'7 | 64'04 | 48'6 |
| 13. Sperm candle, do. - | 14'40 | 8'92 | 7'60 | 5'8 | 61'94 | 47'8 |
| 14. Stearine candle, do. - | 14'30 | 9'35 | 6'00 | 5'5 | 65'24 | 37'1 |
| 15. Coal gas - | 127 | 136 litres | | 5'0 | 107 litres | 3'9 |
| 16. Oil gas - | 127 | 136 do. | | 5'0 | 30 | 3'9 |

The light of the mechanical lamp is greatly over-rated relatively to that of gas. The cost of the former is at least 10 times greater than of the latter, in London.

The leading novelty under this title, is the construction of lamps for burning spirits of turpentine, in the place of the fat oils which alone have been in use from the most remote ages down to the present time. Several patents have recently been obtained for these lamps, under the fantastic title of *Camphine*; one by Mr. William Young, and another by Messrs. Rayner and Carter, as the invention of a working miner—Roberts. Having been employed by the proprietors of these patents to examine the performances of their respective lamps, I here insert the two reports drawn up by me on these occasions:—

“The *Vesta Lamp*, burning with its utmost brilliancy, without smoke, emits a light equal to very nearly twelve wax or sperm candles of three or four to the pound; and in so doing, it consumes exactly one imperial pint of spirits of turpentine (value sixpence retail) in ten hours; hence the cost per hour for a light equal to ten such candles is one halfpenny; whereas that from wax candles would be nearly sixpence; from spermaceti ditto, fivepence; from stearine ditto, fourpence; from Palmer's spreading wick ditto, nearly threepence; from tallow moulds $2\frac{1}{2}d.$; from sperm oil in Carcel's Mechanical French Lamp, $1\frac{1}{2}d.$

“One peculiar advantage of the *Vesta Lamp* is the snowy whiteness of its light, which is such as to display the more delicate colours of natural and artificial objects, flowers, paintings, &c. in their true tints, instead of the degraded hues visible by the light of candles and ordinary oil lamps.

“The size of the flame from which so much light is emitted in the *Vesta Lamp*, is greatly smaller than that of oil or gas Argand flames of equal intensity; a circumstance to be accounted for from the difference in chemical composition between spirits of turpentine and fat oils. The spirits consist entirely of carbon and hydrogen; in the proportion of 88 $\frac{1}{2}$ of the former element, and 11 $\frac{1}{2}$ of the latter, in 100 parts; and they consume 328 parts of oxygen; whereas sperm and other unctuous oils consist of 78 parts of carbon, 11 $\frac{1}{2}$ of hydrogen, and 10 $\frac{1}{2}$ of oxygen, in 100 parts; and these consume

only 287.2 of oxygen, in being burnt; because the oxygen already present in the oil neutralizes 2.6 parts of the carbon and 0.4 of the hydrogen, thus leaving only 85½ parts of the combustible elements for the atmosphere to burn. For this reason, 87½ parts by weight of spirits of turpentine, will consume as much oxygen as 100 parts of sperm oil; and will afford, moreover, a more vivid light, because they contain no oxide, as fat oils do, which serves to damp the combustion. In the spirits of turpentine, the affinity of its elements for oxygen is entire, whereas in fat oil the affinity is partially neutralized by the oxides it contains; somewhat as the flame of spirits of wine is weakened by their dilution with water.

“Among the many applications of science to the useful arts, for which the present age is so honourably distinguished, few are more meritorious than the Camphine lamps, by which we can produce a snow-white flame from the cleanly, colourless spirits of turpentine—a pure combustible fluid, in place of the smearable rank oils which contain a seventh part of incombustible matter. Being so rich in hydro-carbon, the spirits require peculiar artifices for complete consumption and the development of their full power of yielding light without smoke or smell. This point of perfection seems to be happily attained by the invention of the two parallel flat rings, in the Paragon lamp, a larger and smaller, forming a cone round the margin of the wick, which cause a rapid reverberation of the air against the flame: thus consuming every particle of volatilized vapour, and adding energy to the luminous undulations. Hence the patent Paragon lamp in full action emits a light equal to that of sixteen wax candles, three to the pound, but of better quality, approaching in purity to that of the sun-beam,—therefore capable of displaying natural and artificial objects in their true colours. But these lamps are very apt to smoke.

“One imperial pint of rectified spirits of turpentine, value 6d. retail, will burn for twelve hours in this lamp, affording all the time the illumination of eleven wax candles.

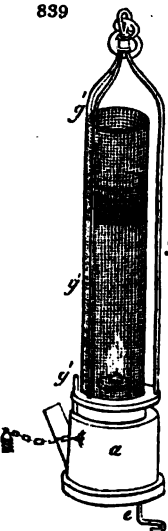
“The Paragon Camphine lamp is attended with no danger in use.

“The Cost, as compared with other Lamps or Candles, is as follows: viz—

| | PER HOUR. |
|---|-----------|
| Paragon Camphine Lamp (equal to 11 wax candles,) less than One Halfpenny. | |
| Wax Candles | 6½d. |
| Spermaceti ditto | 5½ |
| Adamantean Wax (Stearic Acid) | 4½ |
| Palmer's Spread-Wick Candles | 3½ |
| Cocoa Nut Candles | 4½ |
| Moulds (Tallow) | 2½ |
| Carcel's Lamp, with Sperm oil | 2 |

See ILLUMINATION, COST &c, for a description of an excellent oil lamp.

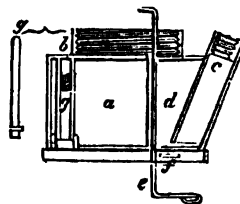
LAMP OF DAVY consists of a common oil lamp, surmounted with a covered cylinder of wire gauze, for transmitting light to the miner without endangering the kindling of the atmosphere of fire-damp which may surround him; because carburetted hydrogen, in passing through the meshes of the cylindric cover, gets cooled by the conducting power of the metallic gauze, below the point of its ascension.



The apertures in the gauze should not be more than 1-20th of an inch square. Since the fire-damp is not inflamed by ignited wire, the thickness of the wire is not of importance, but wire from 1-40th to 1-60th of an inch in diameter is the most convenient.

The cage or cylinder should be made by double joinings, the gauze being folded over in such a manner as to leave no apertures. When it is cylindrical, it should not be more than two inches in diameter; because in larger cylinders the combustion of the fire-damp renders the top inconveniently hot; a double top is always

840



a proper precaution, fixed ½ or ¾ of an inch above the first top. See Fig. 839.

The gauze cylinder should be fastened to the lamp by a screw *b*, fig. 840., of four or five turns, and fitted to the screw by a tight ring. All joinings in the lamp should be made with hard solder; as the security depends upon the circumstance, that no aperture exists in the apparatus, larger than in the wire-gauze.

The parts of the lamp are,

1. The brass cistern *a, d*, *fig. 840.*, which contains the oil. It is pierced at one side of the centre with a vertical narrow tube, nearly filled with a wire which is recurved above, at the level of the burner, to trim the wick, by acting on the lower end of the wire *s* with the fingers. It is called the safety-trimmer.

2. The rim *b* is the screw neck for fixing on the gauze cylinder, in which the wire-gauze cover is fixed, and which is fastened to the cistern by a screw fitted to *b*.

3. An aperture *c* for supplying oil. It is fitted with a screw or a cork, and communicates with the bottom of the cistern by a tube at *f*. A central aperture for the wick.

4. The wire-gauze cylinder, *fig. 839.*, which should not have less than 625 apertures to the square inch.

5. The second top, $\frac{1}{2}$ of an inch above the first, surmounted by a brass or copper plate, to which the ring of suspension may be fixed. It is covered with a wire cap in the figure.

6. Four or six thick vertical wires, *g' g' g' g'*, joining the cistern below with the top plate, and serving as protecting pillars round the cage. *g* is a screw-pin to fix the cover, so that it shall not become loosened by accident or carelessness. The oil-cistern *fig. 840.* is drawn upon a larger scale than *fig. 839.*, to show its minuter parts.

When the wire-gauze safe-lamp is lighted and introduced into an atmosphere gradually mixed with fire-damp, the first effect of the fire-damp is to increase the length and size of the flame. When the inflammable gas forms so much as 1-12th of the volume of the air, the cylinder becomes filled with a feeble blue flame, while the flame of the wick appears burning brightly within the blue flame. The light of the wick augments till the fire-damp increases to 1-6th or 1-5th, when it is lost in the flame of the fire-damp, which in this case fills the cylinder with a pretty strong light. As long as any explosive mixture of gas exists in contact with the lamp, so long it will give light; and when it is extinguished, which happens whenever the foul air constitutes so much as 1-3d of the volume of the atmosphere, the air is no longer proper for respiration; for though animal life will continue where flame is extinguished, yet it is always with suffering. By fixing a coil of platinum wire above the wick, ignition may be maintained in the metal when the lamp itself is extinguished; and from this ignited wire the wick may be again rekindled, on carrying it into a less inflammable atmosphere.

"We have frequently used the lamps where the explosive mixture was so high as to heat the wire-gauze red-hot; but on examining a lamp which has been in constant use for three months, and occasionally subjected to this degree of heat, I cannot perceive that the gauze cylinder of iron wire is at all impaired. I have not, however, thought it prudent, in our present state of experience, to persist in using the lamps under such circumstances, because I have observed, that in such situations the particles of coal dust floating in the air, fire at the gas burning within the cylinder, and fly off in small luminous sparks. This appearance, I must confess, alarmed me in the first instance, but experience soon proved that it was not dangerous.

"Besides the facilities afforded by this invention to the working of coal-mines abounding in fire-damp, it has enabled the directors and superintendents to ascertain, with the utmost precision and expedition, both the presence, the quantity, and correct situation of the gas. Instead of creeping inch by inch with a candle, as is usual, along the galleries of a mine suspected to contain fire-damp, in order to ascertain its presence, we walk firmly on with the safe-lamps, and, with the utmost confidence, prove the actual state of the mine. By observing attentively the several appearances upon the flame of the lamp, in an examination of this kind, the cause of accidents which happened to the most experienced and cautious miners is completely developed; and this has hitherto been in a great measure matter of mere conjecture.

"It is not necessary that I should enlarge upon the national advantages which must necessarily result from an invention calculated to prolong our supply of mineral coal, because I think them obvious to every reflecting mind; but I cannot conclude without expressing my highest sentiments of admiration for those talents which have developed the properties, and controlled the power, of one of the most dangerous elements which human enterprise has hitherto had to encounter."—See Letter to Sir H. Davy, in *Journal of Science*, vol. i. p. 302., by John Buddle, Esq., generally and justly esteemed one of the most scientific coal-miners in the kingdom.

Mr. Buddle, in a letter dated 21st August, 1835, which is published in Dr. Davy's life of his brother Sir Humphrey, says;—

"In the evidence given in my last examination before a committee of the House of Commons, I stated that after nearly twenty years' experience of 'the Davy' with from 1000 to 1500 lamps in daily use, in all the variety of circumstances incidental to coal mining, without a single accident having happened which could be attributed to

a defect in its principle, or even in the rules for its practical application, as laid down by Sir Humphrey — I maintained that 'the Davy' approximated perfection, as nearly as any instrument of human invention could be expected to do. We have ascertained distinctly that the late explosion did not happen in that part of the mine where the Davys were used. They were all found in a perfect state after the accident — many of them in the hands of the dead bodies of the sufferers."

LAMP-BLACK. See **BLACK.**

LAMPATES and LAMPIC ACID. When a spirit of wine lamp has its cotton wick surmounted with a spiral coil of platinum wire, after lighting it for a little, it may be blown out, without ceasing to burn the alcohol; for the coil continues ignited, and a current of hot vapour continues to rise, as long as the spirit lasts. This vapour was first condensed and examined by Professor Daniell, who called it lampic acid. It has a peculiar, strongly acid, burning taste, and a spec. grav. of 1.015. It possesses in an eminent degree the property of reducing certain metallic solutions; such as those of platinum, gold, and silver. The *lampates* may be prepared by saturating the above acid with the alkaline and earthy carbonates. See **ALDEBYDZ.**

LAPIDARY, Art of. The art of the lapidary, or that of cutting, polishing, and engraving gems, was known to the ancients, many of whom have left admirable specimens of their skill. The Greeks were passionate lovers of rings and engraved stones; and the most parsimonious among the higher classes of the Cyrenians are said to have worn rings of the value of ten minas (about 30*l.* of our money.) By far the greater part of the antique gems that have reached modern times, may be considered as so many models for forming the taste of the student of the fine arts, and for inspiring his mind with correct ideas of what is truly beautiful. With the cutting of the diamond, however, the ancients were unacquainted, and hence they wore it in its natural state. Even in the middle ages, this art was still unknown; for the four large diamonds which enrich the clasp of the imperial mantle of Charlemagne, as now preserved in Paris, are uncut, octahedral crystals. But the art of working diamonds was probably known in Hindostan and China, in very remote periods. After Louis de Berghen's discovery, in 1476, of polishing two diamonds by their mutual attrition, all the finest diamonds were sent to Holland to be cut and polished by the Dutch artists, who long retained a superiority, now no longer admitted by the lapidaries of London and Paris.

The operation of gem cutting is abridged by two methods; 1. by cleavage; 2. by cutting off slices with a fine wire, coated with diamond powder, and fixed in the stock of a hand-saw. Diamond is the only precious stone which is cut and polished with diamond powder, soaked with olive oil, upon a mill plate of very soft steel.

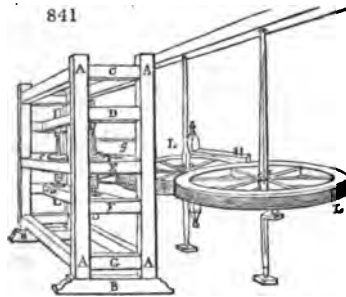
Oriental rubies, sapphires, and topazes, are cut with diamond powder soaked with olive oil, on a copper wheel. The facets thus formed are afterwards polished on another copper wheel, with tripoli, tempered with water.

Emeralds, hyacinths, amethysts, garnets, agates, and other softer stones, are cut at a lead wheel, with emery and water; and are polished on a tin wheel with tripoli and water, or, still better, on a zinc wheel, with putty of tin and water.

The more tender precious stones, and even the pastes, are cut on a mill-wheel of hard wood, with emery and water; and are polished with tripoli and water, on another wheel of hard wood.

Since the lapidary employs always the same tools, whatever be the stone which he cuts or polishes, and since the wheel discs alone vary, as also the substance he uses with them, we shall describe, first of all, his apparatus, and then the manipulations for diamond-cutting, which are applicable to every species of stone.

The lapidary's mill, or wheel, is shewn in perspective in *fig. 841*. It consists of a strong frame made of oak carpentry, with tenon and mortised joints, bound together with strong bolts and screw nuts. Its form is a parallelepiped of from 8 to 9 feet long, by from 6 to 7 high; and about 2 feet broad. These dimensions are large enough to contain two cutting wheels alongside of each other, as represented in the figure.



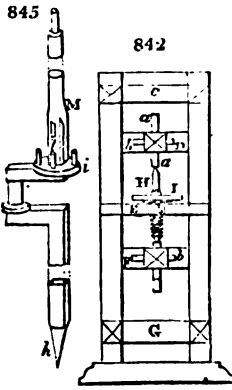
Besides the two sole bars *a* *b*, we perceive in the breadth, 5 cross bars, *c*, *d*, *e*, *f*, *g*. The two extreme bars *c* and *g*, are a part of the frame-work, and serve to bind it. The two cross-bars *d* and *f*, carry each in the middle of their length, a piece of wood as thick as themselves, but only 4½ inches long

(see *fig. 842.*), joined solidly by mortises and tenons with that cross bar as well as

with the one placed opposite on the other parallel face. These two pieces are called *summers* (lintels); the one placed at *n* is the upper; the one at *r*, the lower.

In *fig. 842*. this face is shewn inside, in order to explain how the mill wheel is placed and supported. The same letters point out the same objects, both in the preceding and the following figures.

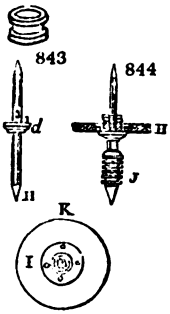
In each of these *summers* a square hole is cut out, exactly opposite to the other; in which are adjusted by friction, a square piece of oak *a a*, *fig. 842.*, whose extremities are perforated with a conical hole, which receives the two ends of the arbor *u* of the wheel *l*, and forms its socket. This square bar is adjusted at a convenient height, by a double wooden wedge *b b*.



The cross bar in the middle *x* supports the table *c c*, a strong plank of oak. It is pierced with two large holes whose centres coincide with the centre of the conical holes hollowed out at the end of the square pins. These holes, of about 6 inches diameter each, are intended to let the arbor pass freely through, bearing its respective wheel. (See one of these holes at *1*, in *fig. 846*. below.)

Each wheel is composed of an iron arbor *u*, *fig. 843.*, of a grinding-wheel *l*, which differs in substance according to circumstances, as already stated, and of the pulley *j*, furnished with several grooves (see *fig. 844.*), which has a square fit upon the arbor. The arbor carries a collet *d*, on which are 4 iron pegs or pins that enter into the wheel to fasten it.

The wheel plate, of which the ground plan is shown at *k*, is hollowed out towards its centre to half its thickness; when it is in its position on the arbor, as indicated in *fig. 844.*, a washer or ferrule of wrought iron is put over it, and secured in its place by a double wedge. In *fig. 844.* the wheel-plate is represented in section, that the connection of the whole parts may be seen.

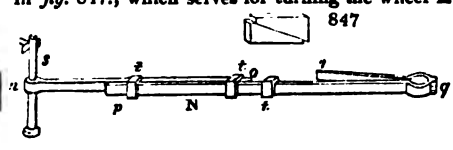
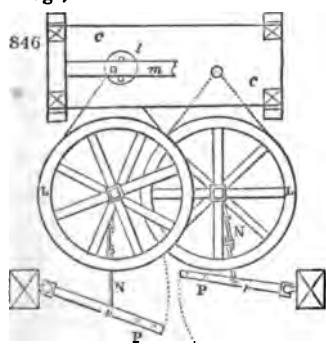


A board *g* (see *fig. 841.* and *fig. 849.*), about 7½ inches high, is fixed to the part of the frame opposite to the side at which the lapidary works, and it prevents the substances made use of in the cutting and polishing, from being thrown to a distance by the centrifugal force of the wheel-plate.

Behind this apparatus is mounted for each grinding-plate, a large wheel *L* (see *fig. 841.*), similar to a cutler's, but placed horizontally. This wheel is grooved round its circumference to receive an endless cord or band, which passes round one of the grooves of the pulley *j*, fixed below the wheel-plate. Hence, on turning the fly-wheel *l*, the plate revolves with a velocity relative to the velocity communicated to the wheel *l*, and to the difference of diameter of the wheel *L* and the pulley *j*. Each wheel *l*, is mounted on an iron arbor, with a crank (see *u*, *fig. 845.*)

The lower pivot of that arbor *A* is conical, and turns in a socket fixed in the floor. The great wheel *L* rests on the collet *i*, furnished with its 4 iron pins, for securing the connection. Above the wheel an iron washer is laid, and the whole is fixed by a double wedge, which enters into the mortise *l*, *fig. 845.*

Fig. 846. exhibits a ground-plan view of all this assemblage of parts, to explain the structure of the machine. Every thing that stands above the upper *summer-bar* has been suppressed in this representation. Here we see the table *c c*; the upper *summer m*; the one wheel-plate *l*, the other having been removed to shew that the endless cord does not cross; the two large wheels *L L*, present in each machine, the crank bar *n*, seen separate in *fig. 847.*, which serves for turning the wheel *L*.



This bar is formed of 9 iron plates *u*, *o*; *p*, *q*; and *q*, *r*; (*fig. 847.*) The first is

bent round at the point *m*, to embrace the stud *s*; the second *p q*, is of the same breadth and thickness as the first; and the third, is adjusted to the latter with a hinge joint, at the point *q*, where they are both turned into a circular form, to embrace the crank *m*. When all these pieces are connected, they are fixed at the proper lengths by the buckles or square rings *t t*, which embrace these pieces, as is shown in *fig* 846.

The stud *s*, seen in *fig* 847., is fixed to the point *v* by a wedge-key upon the arm *r*, represented separately, and in perspective, in *fig* 848. The labourer seizing the two upright pegs or handles *x x*; by the alternate forward and backward motion of his arm, he communicates the same motion to the crank rod, which transmits it to the crank of the arbor *m*, and impresses on that arbor, and the wheel which it bears, a rotatory movement.

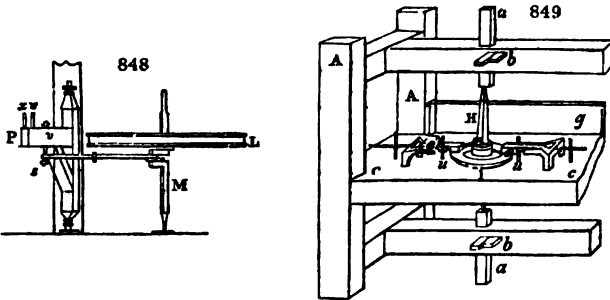


Fig 849. shows piece-meal and in perspective, a part of the lapidary's wheel-mill. There we see the table *c c*, the grind-plate *l*, whose axis is kept in a vertical position by the two square plugs *a a*, fixed into the two *summers* by the wedges *b b*. On the two sides of the wheel-plate we perceive an important instrument called a *dial*, which serves to hold the stone during the cutting and polishing. This instrument has received lately important ameliorations, to be described in *fig* 850. The lapidary holds this instrument in his hand, he rests it upon the iron pins *u u* fixed in the table, lest he should be affected by the velocity of the revolving wheel-plate. He loads it sometimes with weights *e, e*, to make it take better hold of the grinding plate.

One of the most expert lapidaries of Geneva works by means of the following improved mechanism, of his own invention, whereby he cuts and polishes the facets with extreme regularity, converting it into a true dial.

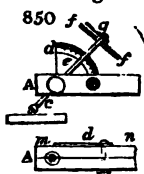


Fig 850. shows this improvement. Each of the two jaws bears a large onchoidal cavity, into which is fitted a brass ball, which carries on its upper part a tube *e*, to whose extremity is fixed a dial-plate *ff*, engraved with several concentric circles, divided into equal parts, like the toothed-wheel cutting engine-plate, according to the number of facets to be placed in each cutting range. The tube receives with moderate friction the handle of the cement rod, which is fixed at the proper point by a thumb-screw, not shown in the figure, being concealed by the vertical limb *d*, about to be described.

A needle or index *g*, placed with a square fit on the tail of the cement rod, marks by its point the divisions on the dial plate *ff*. On the side *m n* of the jaw *A*, there is fixed by two screws, a limb *d*, forming a quadrant whose centre is supposed to be at the centre of the ball. This quadrant is divided as usual into 90 degrees, whose highest point is marked *O*, and the lowest would mark about 70; for the remainder of the arc down to 90 is concealed by the jaw. The two graduated plates are used as follows:—

When the cement rod conceals zero or *O* of the limb, it is then vertical, and serves to cut the table of the brilliant; or the point opposite to it, and parallel to the table. On making it slope a little, 5 degrees for example, all the facets will now lie in the same zone, provided that the inclination be not allowed to vary. On turning round the cement rod the index *g* marks the divisions, so that by operating on the circle with 16 divisions, stopping for some time at each, 16 facets will have been formed, of perfect equality, and at equal distances, as soon as the revolution is completed.

Diamonds are cut at the present day in only two modes; into a rose diamond, and a brilliant. We shall therefore confine our attention to these two forms.

The rose diamond is flat beneath, like all weak stones, while the upper face rises into a dome, and is cut into facets. Most usually six facets are put on the central region,

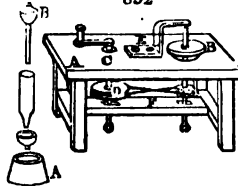
which are in the form of triangles, and unite at their summits; their bases abut upon another range of triangles, which being set in an inverse position to the preceding, present their bases to them, while their summits terminate at the sharp margin of the stone. The latter triangles leave spaces between them which are likewise cut each into two facets. By this distribution the rose diamond is cut into 24 facets; the surface of the diamond being divided into two portions, of which the upper is called the crown, and that forming the contour, beneath the former, is called *dentelle* (lace) by the French artists.

According to Mr. Jefferies, in his Treatise on Diamonds, the regular rose diamond is formed by inscribing a regular octagon in the centre of the table side of the stone, and bordering it by eight right-angled triangles, the bases of which correspond with the sides of the octagon; beyond these is a chain of 8 trapeziums, and another of 16 triangles. The collet side also consists of a minute central octagon, from every angle of which proceeds a ray to the edge of the girdle, forming the whole surface into 8 trapeziums, each of which is again subdivided by a salient angle (whose apex touches the girdle) into one irregular pentagon and two triangles.

To fashion a rough diamond into a brilliant, the first step is to modify the faces of the original octahedron, so that the plane formed by the junction of the two pyramids shall be an exact square, and the axis of the crystal precisely twice the length of one of the sides of the square. The octahedron being thus rectified, a section is to be made parallel to the common base or *girdle*, so as to cut off 5 eighteenths of the whole height from the upper pyramid, and 1 eighteenth from the lower one. The superior and larger plane thus produced is called the *table*, and the inferior and smaller one is called the *collet*; in this state it is termed a *complete square table diamond*. To convert it into a brilliant, two triangular facets are placed on each side of the table, thus changing it from a square to an octagon; a lozenge-shaped facet is also placed at each of the four corners of the table, and another lozenge extending lengthwise along the whole of each side of the original square of the table, which with two triangular facets set on the base of each lozenge, completes the whole number of facets on the table side of the diamond; viz. 8 lozenges, and 24 triangles. On the collet side are formed 4 irregular pentagons, alternating with as many irregular lozenges radiating from the collet as a centre, and bordered by 16 triangular facets adjoining the girdle. The brilliant being thus completed, is set with the table side uppermost, and the collet side implanted in the cavity made to receive the diamond. The brilliant is always three times as thick as the rose diamond. In France, the thickness of the brilliant is set off into two unequal portions; one third is reserved for the upper part or table of the diamond, and the remaining two thirds for the lower part or collet (*culasse*). The table has eight planes, and its circumference is cut into facets, of which some are triangles, and others lozenges. The collet is also cut into facets called *pavillons*. It is of consequence that the pavillons lie in the same order as the upper facets, and that they correspond to each other, so that the symmetry be perfect, for otherwise the play of the light would be false.

Although the rose-diamond projects bright beams of light in more extensive proportion often than the brilliant, yet the latter shows an incomparably greater play, from the difference of its cutting. In executing this, there are formed 32 faces of different figures, and inclined at different angles all round the table, on the upper side of the stone. On the *collet* (*culasse*) 24 other faces are made round a small table, which converts the culasse into a truncated pyramid. These 24 facets, like the 32 above, are differently inclined and present different figures. It is essential that the faces of the top and the bottom correspond together in sufficiently exact proportions to multiply the reflections and refractions, so as to produce the colours of the prismatic spectrum.

The other precious stones, as well as their artificial imitations, called *pastes*, are cut in the same fashion as the brilliant; the only difference consists in the matter constituting the wheel plates, and the grinding and polishing powders, as already stated.



In cutting the stones, they are mounted on the cement-rod *z*, *fig. 851*, whose stem is set upright in a socket placed in the middle of a sole piece at *A*, which receives the stem of the cement-rod. The head of the rod fills the cup of *A*. A melted alloy of tin and lead is poured into the head of the cement-rod, into the middle of which the stone is immediately plunged; and whenever the solder has become solid, a portion of it is pared off from the top of the diamond, to give the pyramidal form shown in the figure at *z*.

There is an instrument employed by the steel polishers for pieces of clock work, and by the manufacturers of watch-glasses for polishing their edges. It consists of a solid oaken table, *fig. 852*. The top is perforated with two holes, one for passing through the pulley and the arbor of the wheel-plate *a*, made either of lead or of hard

wood, according to circumstances ; and the other c for receiving the upper part of the arbor of the large pulley d. The upper pulley of the wheel-plate is supported by an iron prop e, fixed to the table by two wooden screws. The inferior pivots of the two pieces are supported by screw-sockets, working in an iron screw-nut sunk into the summer-bar f. The legs of the table are made longer or shorter, according as the workman chooses to stand or sit at his employment. Emery with oil is used for grinding down, and tin-putty or colcothar for polishing. The workman lays the piece on the flat of the wheel-plate with one hand, and presses it down with a lump of cork, while he turns round the handle with the other hand.

The *Sapphire*, *Ruby*, *Oriental Amethyst*, *Oriental Emerald*, and *Oriental Topaz*, are gems next in value and hardness to diamond ; and they all consist of nearly pure alumina or clay, with a minute portion of iron as the colouring matter. The following analyses show the affinity in composition of the most precious bodies with others in little relative estimation.

| | Sapphire. | Corundum Stone. | Emery. |
|---------------------|-----------|-----------------|--------|
| Alumina or clay - | 98.5 | 89.50 | 86.0 |
| Silica - - - | 0.0 | 5.50 | 3.0 |
| Oxide of iron - - - | 1.0 | 1.25 | 4.0 |
| Lime - - - | 0.5 | 0.00 | 0.0 |
| | 100.0 | 96.25 | 93.0 |

Salamstone is a variety which consists of small transparent crystals, generally six-sided prisms, of pale reddish and bluish colours. The corundum of Battagammana is frequently found in large six-sided prisms : it is commonly of a brown colour, whence it is called by the natives *curradu gallé*, cinnamon stone. The hair-brown and reddish-brown crystals are called adamantine spar. Sapphire and salamstone are chiefly met with in secondary repositories, as in the sand of rivers &c., accompanied by crystals and grains of octahedral iron-ore and of several species of gems. Corundum is found in imbedded crystals in a rock, consisting of indianite. Adamantine spar occurs in a sort of granite.

The finest varieties of sapphire come from Pegu, where they occur in the Capelan mountains near Syrian. Some have been found also at Hohenstein in Saxony, Bilin in Bohemia, Puy in France, and in several other countries. The red variety, the ruby, is most highly valued. Its colour is between a bright scarlet and crimson. A perfect ruby above $3\frac{1}{2}$ carats is more valuable than a diamond of the same weight. If it weigh one carat, it is worth 10 guineas ; 2 carats, 40 guineas ; 3 carats, 150 guineas ; 6 carats, above 1000 guineas. A deep coloured ruby, exceeding 20 carats in weight, is generally called a carbuncle ; of which 108 were said to be in the throne of the Great Mogul, weighing from 100 to 200 carats each ; but this statement is probably incorrect. The largest oriental ruby known to be in the world, was brought from China to Prince Gargarin, governor of Siberia. It came afterwards into the possession of Prince Menzikoff, and constitutes now a jewel in the imperial crown of Russia.

A good blue sapphire of 10 carats is valued at 50 guineas. If it weighs 20 carats, its value is 200 guineas ; but under 10 carats, the price may be estimated by multiplying the square of its weight in carats into half a guinea ; thus, one of 4 carats would be worth $4^2 \times \frac{1}{2}$ G. = 8 guineas. It has been said that the blue sapphire is superior in hardness to the red, but this is probably a mistake arising from confounding the corundum ruby with the spinelle ruby. A sapphire of a barbel blue colour, weighing 6 carats, was disposed of in Paris by public sale for 70*l.* sterling ; and another of an indigo blue, weighing 6 carats and 3 grains, brought 60*l.* ; both of which sums much exceed what the preceding rule assigns, from which we may perceive how far fancy may go in such matters. The sapphire of Brasil is merely a blue tourmaline, as its specific gravity and inferior hardness show. White sapphires are sometimes so pure, that when properly cut and polished they have been passed for diamonds.

The yellow and green sapphires are much prized under the names of *Oriental topas* and *emerald*. The specimens which exhibit all these colours associated in one stone are highly valued, as they prove the mineralogical identity of these varieties.

Besides these shades of colour, sapphires often emit a beautiful play of colours, or *chatoiement*, when held in different positions relative to the eye or incident light ; and some likewise present star-like radiations, whence they are called *star-stones* or *asterias* ; sending forth 6 or even 12 rays, that change their place with the position of the stone. This property so remarkable in certain blue sapphires, is not however peculiar to these gems. It seems to belong to transparent minerals which have a rhomboid for their

nucleus, and arises from the combination of certain circumstances in their cutting and structure. Lapidaries often expose the light-blue variety of sapphire to the action of fire, in order to render it white and more brilliant; but with regard to those found at Expailly in France, fire deepens their colour.

3. *Chrysoberyl*, called by Haüy *Cymophane*, and by others *Prismatic corundum*, ranks next in hardness to sapphire, being 8·5 on the same scale of estimation. Its specific gravity is 3·754. It usually occurs in rounded pieces about the size of a pea, but it is also found crystallised in many forms, of which 8-sided prisms with 8-sided summits are perhaps the most frequent. Lustre vitreous; colour asparagus green, passing into greenish-white and olive-green. It shows a bluish opalescence, a light undulating as it were in the stone, when viewed in certain directions; which property constitutes its chief attraction to the jeweller. When polished, it has been sometimes mistaken for a yellow diamond; and from its hardness and lustre is considerably valued. Good specimens of it are very rare. It has been found only in the alluvial deposits of rivers, along with other species of gems. Thus it occurs in Brasil, along with diamonds and prismatic topaz; also in Ceylon. Its constituents are, alumina 68·66; glucina 16·00; silica 6·00; protoxide of iron 4·7; oxide of titanium 2·66; moisture 0·66, according to Seybert's analysis of a specimen from Brasil. It is moistly but perfectly fusible before the blowpipe, with borax and salt of phosphorus. In composition it differs entirely from sapphire, or the rhombohedral corundum.

4. *Spinelle Ruby*, called *Dodecahedral corundum* by some mineralogists, and *Balas ruby* by lapidaries. Its hardness is 8. Specific gravity 3·523. Its fundamental form is the hexahedron, but it occurs crystallized in many secondary forms: octahedrons, tetrahedrons and rhombohedrons. Fracture conchoidal; lustre vitreous; colour red, passing into blue and green, yellow, brown and black; and sometimes it is nearly white. Red spinelle consists of, alumina 74·5; silica 15·5; magnesia 8·25; oxide of iron 1·5; lime 0·75. Vauquelin discovered 6·18 per cent. of chromic acid in the red spinelle. The red varieties exposed to heat, become black and opaque; on cooling they appear first green, then almost colourless, but at last resume their red colour. *Pleonaste* is a variety which yields a deep green globule with borax.

Crystals of spinelle from Ceylon have been observed imbedded in limestone, mixed with mica, or in rocks containing adularia, which seem to have belonged to a primitive district. Other varieties like the pleonaste occur in the drusy cavities of rocks ejected by Vesuvius. Crystals of it are often found in diluvial and alluvial sand and gravel, along with true sapphires, pyramidal zircon, and other gems, as also with octahedral iron ore, in Ceylon. Blue and pearl-gray varieties occur in Südermannland in Sweden, imbedded in granular limestone. Pleonaste is met with also in the diluvial sands of Ceylon. Clear and finely coloured specimens of spinelle are highly prized as ornamental stones. When the weight of a good spinelle exceeds 4 carats, it is said to be valued at half the price of a diamond of the same weight. M. Brard has seen one at Paris, which weighed 215 grains.

5. *Zircon* or *Hyacinth*. Its fundamental form is an isosceles 4-sided pyramid; and the secondary forms have all a pyramidal character. Fracture conchoidal, uneven; lustre more or less perfectly adamantine; colours, red, brown, yellow, gray, green, white; which with the exception of some red tints, are not bright. Hardness 7·5. Specific gravity 4·5. Zircon and hyacinth consist, according to Klaproth, of almost exactly the same constituents; namely, zirconia 70; silica 25; oxide of iron 5. In the white zirconia there is less iron and more silica. Before the blowpipe the hyacinth loses its colour, but does not melt. The brighter zircons are often worked up into a *brilliant* form, for ornamenting watch cases. As a gem, hyacinth has no high value. It has been often confounded with other stones, but its very great specific gravity makes it to be readily recognized.

6. *Topaz*. The fundamental form is a scalene 4-sided pyramid; but the secondary forms have a prismatic character; and are frequently observed in oblique 4-sided prisms, acuminated by 4 planes. The lateral planes of the prism are longitudinally striated. Fracture conchoidal, uneven; lustre vitreous; colours, white, yellow, green, blue, generally of pale shades. Hardness 8; specific gravity 3·5. Prismatic topaz consists, according to Berzelius, of alumina 57·45; silica 34·24; fluoric acid 7·75. In a strong heat the faces of crystallization, but not those of cleavage, are covered with small blisters, which however immediately crack. With borax, it melts slowly into a transparent glass. Its powder colours the tincture of violets green. Those crystals which possess different faces of crystallization on opposite ends, acquire the opposite electricities on being heated. By friction, it acquires positive electricity.

Most perfect crystals of topaz have been found in Siberia, of green, blue, and white colours, along with beryl, in the Uralian and Altai mountains, as also in Kamschatka; in Brasil, where they generally occur in loose crystals, and pebble forms of bright yel-

low colours; and in Mucla in Asia Minor, in pale straw-yellow regular crystals. They are also met with in the granitic detritus of Cairngorm in Aberdeenshire. The blue varieties are absurdly called *oriental aquamarine* by lapidaries. If exposed to heat, the Saxon topaz loses its colour and becomes white; the deep yellow Brazilian varieties assume a pale pink hue; and are then sometimes mistaken for spinelle, to which, however, they are somewhat inferior in hardness. Topaz is also distinguishable by its double refractive property. Tavernier mentions a topaz, in the possession of the Great Mogul, which weighed 157 carats, and cost 20,000*l.* sterling. There is a specimen in the museum of natural history at Paris which weighs 4 ounces 2 gros.

Topazes are not scarce enough to be much valued by the lapidary.

7. *Emerald* and *Beryl*, are described in their alphabetical places. Emerald loses its lustre by candle-light; but as it appears to most advantage when in the company of diamonds, it is frequently surrounded with brilliants, and occasionally with pearls. Beryl is the aqua-marine of the jewellers, and has very little estimation among lapidaries.

8. *Garnet*. See this stone in its alphabetical place.

9. *Chrysolite*, called *Peridot* by Haiüy; probably the topaz of the ancients, as our topaz was their chrysolite. It is the softest of the precious stones, being scratched by quartz and the file. It refracts double.

10. *Quartz*, including, as sub-species, *Amethyst*, *Rock-crystal*, *Rose-quartz*, *Prase* or *Chrysoprase*, and several varieties of calcedony, as *Cat's eye*, *Plasma*, *Chrysoprase*, *Onyx*, *Sardonyx*, &c. Lustre vitreous, inclining sometimes to resinous; colours, very various; fracture conchoidal; hardness, 7; specific gravity, 2.69.

11. *Opal*, or uncleavable quartz. Fracture, conchoidal; lustre, vitreous or resinous; colours, white, yellow, red, brown, green, gray. Lively play of light; hardness, 5.5 to 6.5; specific gravity, 2.091. It occurs in small kidney-shaped and stalactitic shapes, and large tuberoso concretions. The phenomena of the play of colours in precious opal has not been satisfactorily explained. It seems to be connected with the regular structure of the mineral. Hydrophane, or *oculus mundi*, is a variety of opal without transparency, but acquiring it when immersed in water, or in any transparent fluid. Precious opal was found by Klaproth to consist of silica, 90; water, 10; which is a very curious combination. Hungary has been long the only locality of precious opal, where it occurs near Caschau, along with common and semi-opal, in a kind of porphyry. Fine varieties have, however, been lately discovered in the Faroe islands; and most beautiful ones, sometimes quite transparent, near Gracias a Dios, in the province of Honduras, America. The red and yellow bright coloured varieties of fire-opal are found near Zimapan, in Mexico. Precious opal, when fashioned for a gem, is generally cut with a convex surface; and if large, pure, and exhibiting a bright play of colours, is of considerable value. In modern times, fine opals of moderate bulk have been frequently sold at the price of diamonds of equal size; the Turks being particularly fond of them. The estimation in which opal was held by the ancients is hardly credible. They called it *Paideros*, or Child beautiful as love. Nonius, the Roman senator, preferred banishment to parting with his favourite opal, which was coveted by Mark Antony. Opal which appears quite red when held against the light, is called *girasol* by the French; a name also given to the sapphire or corundum *asterias* or star-stone.

12. *Turquoise*, or *Calaité*. Mineral turquoise, occurs massive; fine-grained impalpable; fracture conchoidal; colour, between a blue and a green, soft, and rather bright; opaque; hardness, 6; spec. grav. 2.83 to 3.0. Its constituents are, alumina, 73; oxide of copper, 4.5; oxide of iron, 4; water, 18; according to Dr. John. But by Berzelius, it consists of phosphate of alumina and lime, silica, oxides of copper and iron, with a little water. It has been found only in the neighbourhood of Nichabour in the Khorassan, in Persia; and is very highly prized as an ornamental stone in that country. There is a totally different kind of turquoise, called *dome turquoise*, which seems to be phosphate of lime coloured with oxide of copper. When the oriental stone is cut and polished, it forms a pleasing gem of inferior value. *Malachite*, or mountain green, a compact carbonate of copper, has been substituted sometimes for turquoise, but their shades are different. Malachite yields a green streak, and turquoise a white one.

13. *Lapis lazuli*, is of little value, on account of its softness.

LAZULITE (Eng. and Fr.; *Lazulith*, Germ.); is a blue vitreous mineral, crystallizing in rhomboidal dodecahedrons; spec. grav. 2.76 to 2.94; scratches glass; affords a little water by calcination; fusible into a white glass; dissolves in acids with loss of colour; solution leaves an alkaline residuum, after being treated with carbonate of ammonia, filtered, evaporated, and calcined. It consists of silica, 35.8; alumina, 34.8; soda, 23.2; sulphur, 3.1; carbonate of lime, 3.1. This beautiful stone affords the native *ultramarine* pigment, which was very costly till a mode of making it artificially was lately discovered. See ULTRAMARINE.

LEAD. (*Plomb*, Fr.; *Blei*, Germ.) This is one of the metals most anciently known

being mentioned in the books of Moses. It has a gray blue colour, with a bright metallic lustre when newly cut, but it becomes soon tarnished and earthy looking in the air. Its texture is close, without perceptible cleavage or appearance of structure; the specific gravity of common lead is 11.352; but of the pure metal, from 11.38 to 11.44. It is very malleable and ductile, but soft and destitute of elasticity; fusible at 612° Fahr., by Crighton, at 634° by Kupfer, and crystallizable on cooling, into octahedrons implanted into each other so as to form an assemblage of four-sided pyramids.

There are four oxides of lead. 1. The suboxide of a grayish blue colour, which forms a kind of crust upon a plate of lead long exposed to the air. It is procured in a perfect state by calcining oxalate of lead in a retort; the dark gray powder which remains is the pure suboxide. 2. The protoxide is obtained by exposing melted lead to the atmosphere, or, more readily, by expelling the acid from the nitrate of lead by heat in a platinum crucible. It is yellow, and was at one time prepared as a pigment by calcining lead; but is now superseded by the chromate of this metal. Litharge is merely this oxide in the form of small spangles, from having undergone fusion; it is more or less contaminated with iron, copper, and sometimes a little silver. It contains likewise some carbonic acid. The above oxide consists of 104 of metal, and 8 of oxygen, its prime equivalent being 112, upon the hydrogen scale; and it is the base of all the salts of lead. 3. The plumbeous suroxide of Berzelius, the sesquioxide of some British chemists, is the well-known pigment called **RED LEAD** or *minium*. It consists of 100 parts of metal and 10 of oxygen. 4. The plumbic suroxide of Berzelius, or the peroxide of the British chemists, is obtained by putting red lead in chlorine water, or in dilute nitric acid. It is of a dark brown, almost black colour, which gives out oxygen when heated, and becomes yellow oxide. It kindles sulphur when triturated with it. This oxide is used by the analytical chemist to separate, by condensation, the sulphurous acid existing in a gaseous mixture.

Among the ores of lead some have a metallic aspect; are black in substance, as well as when pulverized; others have a stony appearance, and are variously coloured, with usually a vitreous or greasy lustre. The specific gravity of the latter ores is always less than 5. The whole of them, excepting the chloride, become more or less speedily black, with sulphuretted hydrogen or with hydrosulphurets; and are easily reduced to the metallic state upon charcoal, with a flux of carbonate of soda, after they have been properly roasted. They diffuse a whitish or yellowish powder over the charcoal, which, according to the manner in which the flame of the blowpipe is directed upon it, becomes yellow or red; thus indicating the two characteristic colours of the oxides of lead.

We shall not enter here into the controversy concerning the existence of native lead, which has been handled at length by M. Brongniart in the *Dictionnaire des Sciences Naturelles*, article *Plomb, Mineralogie*.

The lead ores most interesting to the arts are:—

1. *Galena*, sulphuret of lead. This ore has the metallic lustre of lead with a crystalline structure derivable from the cube. When heated cautiously at the blowpipe it is decomposed, the sulphur flies off, and the lead is left alone in fusion; but if the heat be continued, the coloured surface of the charcoal indicates the conversion of the lead into its oxides. Galena is a compound of lead and sulphur, in equivalent proportions, and therefore consists, in 100 parts, of 86½ of metal, and 13½ of sulphur, with which number the analysis of the galena of Clausthal by Westrumb exactly agrees. Its specific gravity, when pure, is 7.56. Its colour is blackish gray, without any shade of red, and its powder is black; characters which distinguish it from *blende* or sulphuret of zinc. Its structure in mass is lamellar, passing sometimes into the fibrous or granular, and even compact. It is brittle. The *specular galena*, so called from its brightly polished aspect, is remarkable for forming the *slickensides* of Derbyshire—thin seams, which explode with a loud noise when accidentally scratched in the mine.

The argentiferous galena has in general all the external characters of pure galena. The proportions of silver vary from one-fifth part of the whole, as at Tarnowitz, in Silesia, to three parts in ten thousand, as in the ore called by the German miners *Weisgültigers*; but it must be observed, that whenever this lead ore contains above 5 per cent. of silver, several other metals are associated with it. The mean proportion of silver in galena, or that which makes it be considered practically as an argentiferous ore, because the silver may be profitably extracted, is about two parts in the thousand. See **SILVER**. The above rich silver ores were first observed in the Freyberg mines called *Himmelsfurst* and *Beschertgluck*, combined with sulphuret of antimony; but they have been noticed since in the Hartz, in Mexico, and several other places.

The antimonial galena (*Bournonite*) exhales at the blowpipe the odour peculiar to antimony, and coats the charcoal with a powder partly white and partly red. It usually contains some arsenic.

2. The *Seleniuret of lead*, resembles galena, but its tint is bluer. Its chemical characters are the only ones which can be depended on for distinguishing it. At the blowpipe, it exhales a very perceptible smell of putrid radishea. Nitric acid liberates the selenium. When heated in a tube, oxide of selenium of a carmine red rises along with selenic acid, white and deliquescent. The specific gravity of this ore varies from 6·8 to 7·69.

3. *Native minium or red lead*, has an earthy aspect, of a lively and nearly pure red colour, and sometimes inclining to orange. It occurs pulverulent, and also compact, with a fracture somewhat lamellar. When heated at the blowpipe upon charcoal, it is readily reduced to metallic lead. Its specific gravity varies from 4·6 to 8·9. This ore is rare.

4. *Plomb-gomme*. This lead ore, as singular in appearance as in composition, is of a dirty brownish or orange-yellow, and occurs under the form of globular, or gum-like concretions. It has also the lustre and translucency of gum; with somewhat of a pearly aspect at times. It is harder than fluor spar. It consists of oxide of lead, 40; alumina, 37; water, 18·6; foreign matters and loss, 4·06; in 100. Hitherto it has been found only at Huelgoet, near Poullaouen, in Brittany, covering with its tears or small concretions the ores of white lead and galena which compose the veins of that lead mine.

5. *White lead, carbonate of lead*. This ore, in its purest state, is colourless and transparent like glass, with an adamantine lustre. It may be recognised by the following characters:—

Its specific gravity is from 6 to 6·7; it dissolves with more or less ease, and with effervescence, in nitric acid; becomes immediately black by the action of sulphuretted hydrogen, and melts on charcoal before the blowpipe into a button of lead. According to Klaproth, the carbonate of Leadhills contains 82 parts of oxide of lead, and 16 of carbonic acid, in 98 parts. This mineral is tender, scarcely scratches calc-spar, and breaks easily with a waved conchoidal fracture. It possesses the double refracting property in a very high degree; the double image being very visible on looking through the flat faces of the prismatic crystals. Its crystalline forms are very numerous, and are referrible to the octahedron, and the pyramidal prism.

6. *Vitreous lead, or sulphate of lead*. This mineral closely resembles carbonate of lead; so that the external characters are inadequate to distinguish the two. But the following are sufficient. When pure, it has the same transparency and lustre. It does not effervesce with nitric acid; it is but feebly blackened by sulphuretted hydrogen; it first decrepitates and then melts before the blowpipe into a transparent glass, which becomes milky as it cools. By the combined action of heat and charcoal, it passes first into a red pulverulent oxide, and then into metallic lead. It consists, according to Klaproth, of 71 oxide of lead, 25 sulphuric acid, 2 water, and 1 iron. That specimen was from Anglesea; the Wanlockhead mineral is free from iron. The prevailing form of crystallization is the rectangular octahedron, whose angles and edges are variously modified. The sulphato-carbonate, and sulphato tri-carbonate of lead, now called *Leadhillite*, are rare minerals which belong to this head.

7. *Phosphate of lead*.—This, like all the combinations of lead with an acid, exhibits no metallic lustre, but a variety of colours. Before the blowpipe, upon charcoal, it melts into a globule externally crystalline, which by a continuance of the heat, with the addition of iron and boracic acid, affords metallic lead. Its constituents are 80 oxide of lead, 18 phosphoric acid, and 1·6 muriatic acid, according to Klaproth's analysis of the mineral from Wanlockhead. The constant presence of muriatic acid in the various specimens examined is a very remarkable circumstance. The crystalline forms are derived from an obtuse rhomboid. Phosphate of lead is a little harder than white lead; it is easily scratched, and its powder is always gray. Its specific gravity is 6·9. It has a vitreous lustre, somewhat adamantine. Its lamellar texture is not very distinct; its fracture is wavy, and it is easily frangible. The phosphoric and arsenic acids being, according to M. Mitscherlich, isomorphous bodies, may replace each other in chemical combinations in every proportion, so that the phosphate of lead may include any proportion, from the smallest fraction of arsenic acid, to the smallest fraction of phosphoric acid, thus graduating indefinitely into arseniate of lead. The yellowish variety indicates, for the most part, the presence of arsenic acid.

8. *Muriate of lead, Horn-lead, or murio-carbonate*.—This ore has a pale yellow colour, is reducible to metallic lead by the agency of soda, and is not altered by the hydrosulphurets. At the blowpipe it melts first into a pale yellow transparent globule, with salt of phosphorus and oxide of copper; and it manifests the presence of muriatic acid by a bluish flame. It is fragile, tender, softer than carbonate of lead, and is sometimes almost colourless, with an adamantine lustre. Spec. grav. 606. Its constituents, according to Berzelius, are, lead, 25·84; oxide of lead, 57·07; carbonate of lead, 6·25; chlorine, 8·84; silica, 1·46; water, 0·54; in 100 parts. The carbonate is an accidental ingre-

dient, not being in equivalent proportion. Klaproth found chlorine, 13·67; lead, 39·98; oxide of lead, 22·57; carbonate of lead, 23·78.

9. *Arsenate of lead*.—Its colour of a pretty pure yellow, bordering slightly on the greenish, and its property of exhaling by the joint action of fire and charcoal a very distinct arsenical odour, are the only characters which distinguish this ore from the phosphate of lead. The form of the arseniate of lead, when it is crystallized, is a prism with six faces, of the same dimensions as that of phosphate of lead. When pure, it is reducible upon charcoal, before the blowpipe, into metallic lead, with the copious exhalation of arsenical fumes; but only in part, and leaving a crystalline globule, when it contains any phosphate of lead. The arseniate of lead is tender, friable, sometimes even pulverulent, and of specific gravity 5·04. That of Johann-Georgenstadt consists, according to Rose, of oxide of lead 77·5; arsenic acid 12·5; phosphoric acid 7·5, and muriatic acid 1·5.

10. *Red lead, or Chromate of lead*.—This mineral is too rare to require consideration in the present work.

11. *Plomb vaucelinite. Chromate of lead and copper.*

12. *Yellow lead. Molybdate of lead.*

13. *Tungstate of lead.*

Having thus enumerated the several species of lead ore, we may remark, that galena is the only one which occurs in sufficiently great masses to become the object of mining and metallurgy. This mineral is found in small quantity among the crystalline primitive rocks, as granite. It is however among the oldest talc-schists and clay slates that it usually occurs. But galena is much more abundant among the transition rocks, being its principal locality, where it exists in interrupted beds, masses, and more rarely in veins. The blackish transition limestone is of all rocks that which contains most galena; as at Pierreville in Normandy; at Clausthal, Zellerfeldt, and most mines of the Harz; at Fahlun, in Sweden; in Derbyshire and Northumberland, &c. In the transition graywacke of the south of Scotland, the galena mines of Leadhills occur. The galena of the primitive formations contains more silver than that of the calcareous.

The principal lead mines at present worked in the world, are the following: 1. Poullaouen and Huelgöet near Carhaix in France, department of Finisterre, being veins of galena, which traverse a clay slate resting upon granite. They have been known for upwards of three centuries; the workings penetrate to a depth of upwards of 300 yards, and in 1816 furnished 500 tons of lead per annum, out of which 1034 pounds avoirdupois of silver were extracted. 2. At Villeforte and Viallaz, department of the Lozère, are galena mines said to produce 100 tons of lead *per annum*, with 400 kilogrammes of silver (880 liba. avoird.). 3. At Pezey and Macot, to the east of Moutiers in Savoy a galena mine exists in talc-schist, which has produced annually 200 tons of lead, and about 600 kilogrammes of silver (1290 liba. avoird.). 4. The mine of Vedrin, near Namur in the Low Countries, is opened upon a vein of galena, traversing compact limestone of a transition district; it has furnished 200 tons of lead, from which 385 pounds avoird. of silver were extracted. 5. In Saxony the galena mines are so rich in silver as to make the lead be almost overlooked. They are enumerated under silver ores. 6. The lead mines of the Harz have been likewise considered as silver ores. 7. Those of Bleyberg in the Eifel are in the same predicament. 8. The galena mines of Bleyberg and Villach in Carinthia, in compact limestone. 9. In Bohemia, to the south-west of Prague. 10. The mines of Joachimsthal, and Bleystadt, on the southern slope of the Erzgebirge, produce argentiferous galena. 11. There are numerous lead mines in Spain, the most important being in the granite hills of Linarès, upon the southern slope of the Sierra Morena, and in the district of the small town of Canjagar. Sometimes enormous masses of galena are extracted from the mines of Linarès. There are also mines of galena in Catalonia, Grenada, Murcia, and Almeria, the ore of the last locality being generally poor in silver. 12. The lead mines of Sweden are very argentiferous, and worked chiefly with a view to the silver. 13. The lead mines of Daouria are numerous and rich, lying in a transition limestone, which rests on primitive rocks; their lead is neglected on account of the silver.

14. Of all the countries in the world, Great Britain is that which annually produces the greatest quantity of lead. According to M. Villofosse, in his *Richesse Minérales*, published in 1819, we had furnished every year 12,500 tons of lead, whilst all the rest of Europe taken together did not produce so much; but from more recent documents, that estimate seems to have been too low. Mr. Taylor (in 1823) rated the total product of the United Kingdom *per annum* at 31,900 tons, a quantity fully 2½ times greater than the estimate of Villofosse (see Conybeare and Phillips' *Geology*, p. 354). Mr. Taylor distributed this product among the different districts as follows:—

| | |
|--|---------------|
| Wales, (Flintshire and Denbighshire) - - - | Tons. |
| Scotland, (in transition graywacke) - - - | 7,500 |
| Durham, Cumberland, and Yorkshire, (in carboniferous lime) - | 2,800 |
| Derbyshire, (probably in carboniferous lime) - - - | 19,000 |
| Shropshire - - - - - | 1,000 |
| Devon and Cornwall, (transition and primitive rocks) - - | 800 |
| Total - - - - - | 31,900 |

We thus see that Cumberland, and the adjacent parts of the counties of Durham and York, furnish of themselves nearly three-fifths of the total product. Derbyshire was formerly much more productive. In Cornwall and Devonshire, the lead ore is found in veins in *killas*, a clay-slate passing into graywacke. In North Wales and the adjacent counties, as well as in Cumberland and Derbyshire, the lead occurs in the carboniferous limestone.

In 1835, the total produced was estimated, by Mr. Taylor at 46,112 tons; of which 19,626 were furnished by Northumberland, Durham, and Cumberland; the mines of Mr. Beaumont alone, yielding 10,000. In 1847, the total produce was as follows: —

| | Lead Ore. | Lead. |
|--------------------|---------------|---------------|
| | Tons. | Tons. |
| England - - - | 59,614½ | 39,507½ |
| Wales - - - | 18,147½ | 12,294 |
| Ireland - - - | 2,251 | 1,380 |
| Scotland - - - | 1,159 | 822½ |
| Isle of Man - - - | 2,575 | 1,699 |
| Total - - - | 83,747 | 55,708 |

The English lead-miners distinguish three different kinds of deposits of lead ore; *rake-veins*, *pipe-veins*, and *flat-veins*. The English word vein corresponds to the French term *flos*; but miners make use of it indifferently in England and France, to indicate all the deposits of this ore, adding an epithet to distinguish the different forms; thus, *rake-veins* are true veins in the geological acceptation of the word vein; *pipe-veins* are masses usually very narrow, and of oblong shape, most frequently parallel to the plane of the rocky strata; and *flat-veins* are small beds of ores interposed in the middle of these strata.

Rake-veins are the most common form in which lead ore occurs in Cumberland. They are in general narrower in the sandstone which covers the limestone, than in the calcareous beds. A thickness of less than a foot in the former becomes suddenly 3 or 4 feet in the latter; in the rich vein of Hudgillburn, the thickness is 17 feet in the *Great limestone*, while it does not exceed 3 feet in the overlying *Watersill* or sandstone. This influence exercised on the veins by the nature of the enclosing rock, is instructive; it determines at the same time almost uniformly their richness in lead ore, an observation similar to what has been made in other countries, especially in the veins of Kongsburg in Norway. The Cumberland veins are constantly richer, the more powerful they are, in the portions which traverse the calcareous rocks, than in the beds of sandstone, and more particularly the schistose rocks. It is rare in the rock called *plate* (a solid slaty clay) for the vein to include any ore; it is commonly filled with a species of potter's earth. The upper calcareous beds are also in general more productive than the lower ones. In most of these mines, the veins were not worked till lately below the fifth calcareous bed (the four-fathom limestone), which is 307 yards beneath the millstone-grit; and as the first limestone stratum is 106 yards beneath it, it follows that the thickness of the part of the ground where the veins are rich in lead does not in general exceed 200 yards. It appears however that veins have been mined in the neighbourhood of Alston Moor, downwards to the eleventh calcareous stratum, or Tyne bottom limestone, which is 418 yards under the millstone-grit of the coal formation, immediately above the whin-sill; and that they have been followed above the first limestone stratum, as high as the grindstone sill, which is only 83 yards below the same stratum of millstone-grit; so that in the total thickness of the plumbiferous formation there is more than 396 yards. It has been asserted that lead veins have been traced even further down, into the *Momerby* scar limestone; but they have not been mined.

The greatest enrichment of a vein takes place commonly in the points where its two sides, being not far asunder, belong to the same rock; and its impoverishment occurs when one side is calcareous and the other a schistose clay. The minerals which most

frequently accompany the galena, are carbonate of lime, fluats of lime, sulphate of baryta, quartz, and pyrites.

The pipe-veins (*amas* in French), are seldom of great length; but some have a considerable width; their composition being somewhat similar to that of the *rake-veins*. They meet commonly in the neighbourhood of the two systems, sometimes being in evident communication together; they are occasionally barren; but when a wide pipe-vein is metalliferous, it is said to be very productive.

The *flat veins*, or *strata veins*, seem to be nothing else than expansions of the matter of the vein between the planes of the strata; and contain the same ores as the veins in their vicinity. When they are metalliferous, they are worked along with the adjacent rake vein; and are productive to only a certain distance from that vein, unless they get enriched by crossing a rake vein. Some examples have been adduced of advantageous workings in *flat veins* in the *great limestones* of Cumberland, particularly in the mines of Coalcleugh and Neuthead. The *rake veins*, however, furnish the greater part of the lead which Cumberland and the adjacent counties send every year into the market. Mr. Forster has given a list of 165 lead mines, which have been formerly, or are now worked in that district of the kingdom.

The metalliferous limestone occupies, in Derbyshire, a length of about 25 miles from north-west to south-east, under a very variable breadth, which towards the south amounts to 25 miles. Castleton to the north, Burton to the north-west, and Matlock to the south-east, lie nearly upon its limits. It is surrounded on almost all sides by the millstone grit which covers it, and which is, in its turn, covered by the coal strata. The nature of the rocks beneath the limestone is not known. In Cumberland the metalliferous limestone includes a bed of trap, designated under the name of *whinsill*. In Derbyshire the trap is much more abundant, and it is thrice interposed between the limestone. These two rocks constitute of themselves the whole mineral mass, through a thickness of about 550 yards, measuring from the millstone grit; only in the upper portion, that is near the millstone grit, there is a pretty considerable thickness of argillaceous schists.

Four great bodies or beds of limestone are distinguishable, which alternate with three masses of trap, called toadstone. The lead veins exist in the calcareous strata, but disappear at the limits of the toadstone. It has now been ascertained, however, that they recur in the limestone underneath.

LEAD IN THE EXHIBITION. — Sopwith, Thomas, F. R. S., &c., Allenheads, Northumberland, inventor and producer.

Specimens of lead ores and associated minerals, with examples of the various stages of progress from their being excavated in the mine and carried through the several departments of washing and smelting, until furnished and ready for the market in the form of a cake of silver and a pig or piece of lead known as W. B. lead.

The specimens of minerals usually associated with lead ores are collected from various mines, and are fitted together in a separate case, under the direction of the exhibitor, by Messrs. Cain and Wallace of Neuthead, and others.

The general arrangement of the strata in which these ores and minerals are found is exhibited by a section of part of the lead mining district belonging to Wentworth Blackett Beaumont, Esq., at Allenheads, in the county of Northumberland, and from whose mines the specimens of lead ores and examples of process during conversion into lead and silver are taken; and a further illustration of the geological structure of this part of England is given by an isometrical plan and section by the exhibitor, showing a considerable tract of mining ground in the manor of Alston Moor, in the county of Cumberland.

The principal phenomena of mineral veins and displacement of the strata in which lead ore is obtained in the north of England are shown by dissected models, invented by the exhibitor, and examples of the finished products are contained in a separate case, from Mr. Beaumont's smelt-mills, under the direction of his agent, Mr. Thomas Steel.

This collection, the general nature of which is here briefly indicated, is intended to illustrate the geological position and usual products of the north of England lead mines.

The following is the order of the five several portions, and which are more particularly described under these several heads in the sequel.

1. Sections of strata at Allenheads and Alston.
2. Models to illustrate mineral veins, &c.
3. Minerals associated with lead ores.
4. Examples of the various stages of progress from the mine to the market.
5. Lead and silver prepared for sale.

1. As the express object of this collection is to afford a general view of the whole of the principal features relative to the extensive and important departments of British industry connected with lead mining, and as this information is more expressly intended for the use of those who are not locally conversant with the physical conditions under

which lead ores are usually obtained, the exhibitor has in the first instance thought it necessary to present clear and distinct views of the geological structure of the districts in which the chief lead mines of the north of England are situated, in order that, without going into purely technical details, which are only of local interest, the several strata and order of superposition may be readily understood.

As an approximate comparative view of the produce, it may be considered that the lead raised in Mr. Beaumont's mines amounts to about one-fourth of the quantity raised in England, about one-sixth of the produce of Great Britain, and about one-tenth of that of the whole of Europe, including the British Isles. They have been extensively worked from time immemorial; part of them are situated in the manors belonging to Mr. Beaumont in the dales of East and West Allen, in the south-west part of Northumberland, and others are situated in the wild district of moors which forms the western extremity of the county of Durham.

This part of the country happens to be at once the centre of the island of Great Britain, and by far the most elevated part of it which is thickly populated; for, scattered over hills and dales, which present an aspect of verdant cultivation mixed with heathy moors, are to be found some thousands of inhabitants, nearly the whole of them either employed in lead mines or smelting-mills, or indirectly deriving a livelihood from some connection with lead-mining business. Allenheads forms a central position in the midst of these mines; and the agent's house, shown on the section, is exactly 1,400 feet above the level of the sea, and is the highest house of its magnitude in Great Britain; nor are many of the cottages of shepherds and other moorland habitations of greater elevation.

The datum or base line of the Allenheads section is 700 feet above the level of the sea. The drawing, 16½ feet in length, is on a true scale of 100 feet to an inch; by a true scale being meant, that the lengths and heights are projected to the scale or proportion, so that a true miniature profile of the country is given, as well as a correct reduction of the relative size of the various rocks. The extent of country thus shown is not quite 4 miles, being 3 miles 1,220 yards.

The spectator is supposed to be looking to the north, and the section commences at a point about half a mile eastward from a place called Kilhope Head, which is conspicuously marked in all English maps, inasmuch as the three counties of Northumberland, Durham, and Cumberland all meet in one spot. At about three quarters of a mile from the point of commencement, the section represents the hill called Kilhope Law; it is on the boundary line of the counties of Northumberland and Durham, and is the highest point of land in the last-named county, being 2,306 feet above the level of the sea. But out of the limits of this section, and about 10 miles south-west from Kilhope Law, the same strata which are here delineated reach an altitude of 2,901 feet above the sea, and this is the highest elevation attained by the rocks which form the carboniferous or mountain limestone of the north of England.

Such being the stratification of the central portion of the narrow part of the island of which the coal fields of the Tyne and Wear form the extremity on the east bordering of the German Ocean, for some distance north and south of Newcastle, while a similar coal field is found at the western extremity near Whitehaven, it may be observed with reference to these coal fields, that they lie over or upon the mountain limestone formation. The coal beds so extensively worked in the Newcastle and Durham coal mines or collieries gradually rise to the west, and one by one crop out or basset according to the undulations of the country. At length, at about 20 miles west of the German Sea, the lowest of the coal beds crops out, and from beneath it gradually appear the limestone strata, which continue to rise nearly coincident with the general rise of the country until they reach the summit of Cross Fell (2,901 feet). And this general and very gradual inclination of the strata, a feature of the greatest importance in practical mining, is clearly and accurately delineated in this section.

In a thickness of about 2,000 feet of the alternating beds of sandstone, clay, and limestone which form the strata of the mining districts of Alladale, Alston, and Wear-dale, there is one single stratum of limestone, called the "great limestone," the veins in which have produced nearly, if not quite, as much ore as all the other strata put together. This stratum is delineated on the section, and may be observed lying at a depth of about 850 feet below the summit of Kilhope Law. Somewhat exceeding 2 miles eastward of this, at Allenheads, the top of the great limestone is 230 feet from the top of a shaft called Gin-Hill Shaft. Its thickness, which is tolerably uniform over several hundred square miles of country, is about 60 feet; and it is from this stratum of limestone that nearly all the specimens in this collection have been obtained.

The dislocations of strata which constitute for the most part important mineral veins are exhibited more in detail in the series of geological models which form a part of this collection; but some of the great features of displacement may be noticed on the section.

At about a quarter of a mile to the west of, or left hand direction from Killhope Law, the great limestone, and all other associated beds, are thrown down a depth of about 150 feet for a space of nearly 700 feet; and again, at the distance of nearly a mile from Allenheads, a vast dislocation takes place, by which the great limestone, it will be seen, is brought nearly to the surface, the amount of displacement being about 400 feet. It is in the great limestone that by far the most extensive portion of the workings of Allenheads lead mines are situated, and the galleries drawn on the section convey a general idea of the position of the mines. In a great thickness of strata above the great limestone, only two beds of that rock are found. One of these is called "little limestone." It is from 10 to 12 feet thick, and is 75 feet above the top of the great limestone. The other is still more inconsiderable, being only 3 or 4 feet thick, and is 440 feet above the great limestone. It is remarkable with what exactness this thin bed is found near the summit of hills, the intervening spaces having apparently been removed by denudation, so as to form in one case a gap of $6\frac{1}{2}$ miles, and in another of $1\frac{1}{2}$ miles, in which the Tell Top limestone is entirely cut off.

But beneath the great limestone, as will be seen by the lines of blue colour, are several beds of the same description of rock, viz., at distances respectively of 30, 106, 190, 250, and 287 feet, and the thickness 2, 24, 10, 15, and 35 feet. These are known by descriptive local names, and comprise all that are of significance as regards lead mining operations.

The Allenheads mines being situated for the most part at depths from the surface varying from 200 to 600 feet are drained, partly by ordinary water-wheels, some of which are shown on the section, and partly by the new hydraulic engines invented by Mr. W. G. Armstrong, and four of which are now in use for draining and other mining purposes at Allenheads mines.

Examples of the various Stages of Progress from the Mine to the Market. — This part of the collection is arranged in five cases, each containing six boxes of one square foot each, being in all thirty boxes.

Fifteen of these boxes, in a line furthest from the front edge of the counter, contain specimens of lead mining from the excavation of the ore in the mine, and showing the several stages of progress until ready to send to the smelt mill; and the other fifteen boxes, in a line nearest to the front of the counter, contain specimens of the ore as prepared for smelting, and its various stages of progress until manufactured into lead and the silver separated; these finished products being contained in division No. 5. of this collection.

Case No. 1. — Lead ore, as first separated from the vein in which it is found, and which in this state is called "bouse" in the north of England lead mines, and the places in which it is deposited at the surface are called bouse teams. The depositing of the ore in these places is greatly facilitated at Allenheads by the use of tipping-frames of a new construction, by Mr. W. G. Armstrong, of the Elswick Engine Works, near Newcastle-on-Tyne. This example is from a "flat" vein in Allenheads mines in the great limestone, which rock forms the curiously laminated matrix with which the ore is intermixed. The ore and rock thus intermixed require to be separated as is exhibited by the following examples. By a flat vein, or "flatta," is meant a horizontal extension of mineral substances to a considerable distance from the ordinary vertical or steeply-inclined veins, which extend in the manner of fissures through the various beds of rock forming the district. The regular lamination of the ore is worthy of attention, as leading to speculations on the origin of mineral veins; a subject of great practical importance. The example here shown is taken from a part of the "flatt workings" at a distance of about 20 feet from the principal or nearly vertical part of the vein.

Case No. 2. — Bouse, or lead ore, as extracted from the vein, and showing an example of the curiously polished surface, which is a frequent characteristic of veins, and which would appear at first sight to have been very carefully polished by artificial means, many of the surfaces being sufficiently clear to reflect the images of objects in a tolerably definite form. The local name of such bright and polished surfaces is "*slickensides*;" and the suggestion mentioned in the notice of the last specimen as to the value of scientific inquiry applies with still greater force to the class of phenomena of which this is one of the most curious indications.

Case No. 3. contains a portion of the ordinary bouse or ore as newly worked from the vein, and much intermixed with the materials contained in Cases 1. and 2., as well as with other earthy and sparry contents of veins. The produce of mineral veins varies from pure galena, of which some species are shown, to masses of rock in spar, in which the ore is so thinly disseminated as not to repay the trouble of extraction.

Case No. 4. — The intermixed rocks and ores shown in preceding cases are first subjected to "picking" and then to "washing" on a grate. The first of these operations separates from the general mass all such pieces of galena as are either not mixed with the other substances, or which can be readily separated with a hammer on what are called

"knocking stones;" and the second has the effect of clearing away all earthy matter. These specimens, picked from the heap and washing-grate, are ready for smelting after being reduced with a hammer to the size of the ore contained in Case No. 9.

Case No. 5. contains ordinary bouse or lead ore taken from the *trunking-box* after passing through the *washing-grate*, being, in fact, a process of *washing and sizing* with a view to the further operations exhibited in the following cases.

Case No. 6. contains specimens of ordinary bouse, which, from the size of the pieces and intermixture of rock and ore, require to be passed through the rollers of the crushing-mill.

Case No. 7.—Specimens of the same bouse or ore after having passed through the rollers of the crushing-mill.

Case No. 8.—So far the processes have consisted simply of extraction of the ore from its place in the mine,—of the pure samples of ore being picked out and washed and sized ready for being smelted at once without further operations,—of the remainder of poorer samples being washed and separated by an iron grate or sieve into two sizes, the larger having to be ground between rollers to reduce it to the same size as the smaller, which had passed the grate; and when reduced to this stage, the whole is ready for an operation called "hotching," which consists in placing the ore in a tub with water. The bottom of this tub is a sieve,—and the whole is subjected to a rapid vibratory vertical movement or shaking, by which a separation of the ore takes place. The water so far lessens the weight as greatly to facilitate the downward movement of the ore, which of course is much heavier than the spar and other materials connected with it. The vibratory movement is sometimes given by manual labour: a long arm moving with a spring is jerked up and down by a strong lad jumping on a raised stand so as to produce the required motion. The same results may be obtained by machinery; and a model of a hotching apparatus accompanies these specimens. It represents the mode in which the hotching tubs are worked in some of Mr. Beaumont's mines in West Allendale; and both the mode of applying the machinery, and the manufacture of the model representing it, are due to the ingenuity of Mr. Joseph Hetherington, one of the engineers or wrights employed at these mines.

The ore is prepared as has already been described; and after being shaken in the "hotching tub," the upper part is entirely waste or refuse, and is called "cuttings," of which this case (No. 8.) contains a specimen.

Case No. 9. contains lead ore as obtained from the bottom of the hotching-tub, and is ready for being smelted.

Case No. 10. contains what is called "undressed smeddum," being what has passed through the sieve of the hotching-tub into the box or case of water in which the hotching-tub vibrates.

Case No. 11. is the "smeddum," after being dressed or cleared from all foreign substances in what is locally called a "buddle," and the ore in being so washed is said to be "buddled."

Case No. 12. In all operations where a stream of running water is employed to wash lead ore, it is obvious that many of the smaller particles will be carried away with the stream. These particles are allowed to settle by their specific gravity in what are called slime pits, being merely reservoirs in which the water passes over a long space with a very tranquil movement. In the Case No. 12. is an example of the slime or deposit in these slime pits undressed.

Case No. 13. contains a specimen of what is called slime ore, having been extracted or separated from the slime shown in Case No. 12. The separation is effected by manual labour in what are called "nicking-trunks," and is made ready for a final washing or separation in the "dolly-tub."

Case No. 14. contains slime obtained, not by manual labour, but by means of a patented invention of Mr. Bruton's, by which the slime, being first freely mixed with water, is allowed on a revolving canvas cloth, inclined at a moderate angle, and upon which also drops of water are constantly falling so as to keep the surface well wetted. Heavier particles, being thus free to move, are carried up the slightly inclined surface of the canvas, and pass round a roller to a cistern below, in which they are deposited while the lighter particles of earthy matter and spar are at once carried down the canvas by the stream of water. The ore thus obtained requires finally to be washed in the dolly tub, after which it is fit for being smelted.

Case No. 15. contains slime ore as taken from the dolly tub, which is the last operation connected with the washing and dressing of lead ores as usually practised in the lead mines belonging to Mr. Beaumont, and in the lead mines generally of this part of the kingdom.

The German buddle is also occasionally used in dressing slime ores. A considerable improvement was made in this apparatus about thirty years ago by Mr. Robert Stagg, of Middleton-in-Teesdale.

Case No. 16. exhibits a specimen of "selected" or superior lead ore in the form in which it is sent to and deposited at the smelt mill ready to be smelted.

Case No. 17. contains an example of the ordinary or common lead ore as prepared and ready for smelting.

Cases Nos. 18. and 19. contain the same ores (selected and common) after having undergone the operation of being "roasted," or exposed to suitable temperature in a reverberatory furnace, the object being to free it from the sulphur contained in the galena, pure specimens of which consist of lead 86.6 and sulphur 13.3.

By this process the ore is rendered more easily reducible.

Case No. 20. Gray slags formed in the process of ore hearth smelting, and from which the lead is afterwards obtained at the slag hearth.

Case No. 21. Black slags being the residuum obtained from the slag hearth, and which assume the granulated form from being made to flow, when in a melted state, into water.

Cases Nos. 22. and 23. contain examples of the crystals of selected and common lead as formed in the process of separating or desilvering the ore: patented by Mr. H. L. Pattinson, and first brought into operation at Mr. Beaumont's smelt mills.

Cases Nos. 24, 25, and 26. contain specimens of the fume or deposit in the long flues connected with the smelt mills; that in No. 24. being the ordinary fume collected in the flue: No. 25. the same, after being roasted for the ore hearth, and No. 26. the same roasted for the slag hearth. The flues or chimneys are built of stone, 8 feet by 6 feet inside, and upwards of 8½ miles long.

Cases Nos. 27, 28, and 29. Litharge in the ordinary round state, and two varieties of lincsed litharge which have been passed through a sieve.

Case No. 30. Skimmings from the surface of melted lead, showing iridescent hues, which are frequently of great intensity and beauty.

A brief statement of the quantity of coals consumed per month in a few of the principal mines will show the extent to which steam power is now employed.

| | | | | | |
|---------------------|---|---|---|---|---------|
| Fowey Consols, 1835 | - | - | - | - | 101,246 |
| Godolphin, 1839 | - | - | - | - | 129,801 |
| Fowey Consols, 1840 | - | - | - | - | 203,699 |
| United Mines, 1842 | - | - | - | - | 84,862 |

The lead mines of Cornwall have produced of the argentiferous sulphuret, during five years, the following number of tons of ore:—

| | 1845. | 1846. | 1847. | 1848. | 1849. |
|------------------------|-------|-------|-------|-------|-------|
| Collington | 950 | 1,138 | 1,249 | 957 | 625 |
| Huel Mary Ann | - | 166 | 192 | 334 | 873 |
| Cornubian | 420 | - | - | - | - |
| E. and W. Haven | 16 | - | - | - | - |
| Huel Trelawney | 280 | 529 | 883 | 413 | 1,296 |
| Camelford | 180 | - | - | - | - |
| E. Huel Rose | 7,883 | 5,191 | 6,424 | 5,333 | 4,758 |
| W. Huel Rose | - | - | 84 | 90 | 75 |
| Cargol | 55 | 306 | 954 | 964 | 505 |
| Oxnam's | - | 188 | 47 | 470 | 269 |
| Huel Rose | 57 | 375 | 378 | 399 | 107 |
| Huel Penrose | 116 | 11 | - | - | - |
| Holmbush | - | 12 | 60 | 154 | 102 |
| New Quay | 73 | - | - | - | - |
| Porthleven | 8 | 82 | - | - | - |
| Pentire | - | 34 | - | - | - |
| Cubert | - | 136 | 354 | 68 | - |
| Leman | - | 30 | 73 | - | - |
| Huel Concord | - | 30 | 30 | - | - |
| Huel Trehane | - | - | 312 | - | 459 |
| Herodscombe | - | - | 37 | - | - |
| Herodsfoot | - | - | 375 | 721 | 1,050 |
| Great Callestock Moors | - | - | 109 | - | - |
| Callestock | - | - | 116 | 179 | - |
| Treyorden | - | - | - | - | 28 |
| Huel Penhale | - | - | - | - | 50 |
| Huel Golden | - | - | - | - | 80 |
| Earthen Consols | - | - | - | - | 45 |

Mines were worked at an early period in the Isle of Man; but the neighbourhood of Laxey first attracted attention at the commencement of the present century. In 1811 only three hands were employed; in 1848 there were at least 800 in the mine. The mine is situated about a mile and a half from the sea, up the Laxey Valley, where an adit is driven 400 fathoms into the heart of the mountain. From this adit the shaft has been sunk about 130 fathoms. The returns of lead ore for the last five years has been as follows:—

| Years. | Lead Ore. | |
|------------|-----------|-------|
| | Tons. | Lead. |
| 1845 - - - | 327 | 155 |
| 1846 - - - | 220 | 104 |
| 1847 - - - | 375 | 247 |
| 1848 - - - | 695 | 461 |
| 1849 - - - | 815 | 546 |

In addition to this, about 200 tons of the sulphuret of zinc are annually raised.

The Cardiganshire mines were worked at a very early period, probably by the Romans. Henry VII. encouraged mining by several grants, involving privileges to those who would work these mines. In the reign of Queen Elizabeth there was a grant made of all these mines to Thomas Thurland and Daniel Houghsetter, Germans, who worked them for some time. They eventually passed into the hands of Sir Hugh Middleton, who realized a large profit by working them.

The present value of the Cardiganshire mines will be seen by the following list of their produce:—

| Mines. | Lead Ore Returns. | | Lead Returns. | |
|-------------------------------------|-------------------|-------|---------------|-------|
| | Tons. | Cwts. | Tons. | Cwts. |
| Lisburne Mines - - - - - | 2,733 | 0 | 1,804 | 0 |
| Cwm-y-stwyth - - - - - | 583 | 0 | 333 | 0 |
| Esgair-hir - - - - - | | | | |
| Cwm-sebon - - - - - | 55 | 0 | 33 | 0 |
| Llanfair Clydogan - - - - - | 206 | 0 | 134 | 0 |
| Goginan - - - - - | 1,160 | 0 | 766 | 0 |
| Gogerddan Mines - - - - - | 131 | 0 | 87 | 0 |
| Nanty-y-creiau - - - - - | | | | |
| Pen-y-bout-pren - - - - - | 12 | 0 | 7 | 0 |
| Cefn-cwm-bruzno - - - - - | 10 | 0 | 7 | 0 |
| Bwlch Consols - - - - - | 635 | 0 | 425 | 0 |
| Nanteos - - - - - | 177 | 0 | 106 | 0 |
| Aberystwyth (small mines) - - - - - | 31 | 0 | 20 | 0 |
| Llanymaror - - - - - | | | | |
| Llanbadarn - - - - - | | | | |
| Bron-berllan - - - - - | | | | |
| Brynarian - - - - - | 40 | 0 | 28 | 0 |
| Cwm-erfin - - - - - | 116 | 0 | 78 | 0 |
| Daren - - - - - | 29 | 0 | 20 | 0 |
| Eisteddfodd - - - - - | 40 | 15 | 14 | 0 |
| Llwyn Malys - - - - - | 32 | 0 | 21 | 0 |
| Bwlch-cwm-erfin - - - - - | 18 | 0 | 12 | 0 |

Treatment of the Ores of Lead.

The mechanical operations performed upon the lead ores in Great Britain, to bring them to the degree of purity necessary for their metallurgic treatment, may be divided into three classes, whose objects are,—

1. *The sorting and cleansing of the ores;*
2. *The grinding;*
3. *The washing, properly so called.*

The apparatus subservient to the first objects are sieves, running buddles, and gratings. The large sieves employed in Derbyshire for sorting the ore at the mouth of the mine into coarse and fine pieces, is a wire gauze of iron; its meshes are square, and an inch long in each side. There is a lighter sieve of wire gauze, similar to the preceding, for washing the mud from the ore, by agitating the fragments in a tub filled with water.

But in Derbyshire, instead of using this sieve, the pieces of ore are sometimes merely stirred about with a shovel, in a trough filled with water. This is called a *standing buddle*; a most defective plan.

The *running buddle* serves at once to sort and cleanse the ore. It consists of a plane surface made of slabs or planks, very slightly inclined forwards, and provided behind and on the sides with upright ledges, the back one having a notch to admit a stream of water. The ore is merely stirred about with a shovel, and exposed on the slope to the stream. For this apparatus, formerly the only one used at the mines of Alston Moor, the following has been substituted, called the *grate*. It is a *grid*, composed of square bars of iron, an inch thick, by from 24 to 32 inches long, placed horizontally, and parallelly to each other, an inch apart. There is a wooden canal above the grate, which conducts a stream of water over its middle; and an inclined plane is set beneath it, which leads to a hemispherical basin, about 24 inches in diameter, for collecting the metallic powder washed out of the ore.

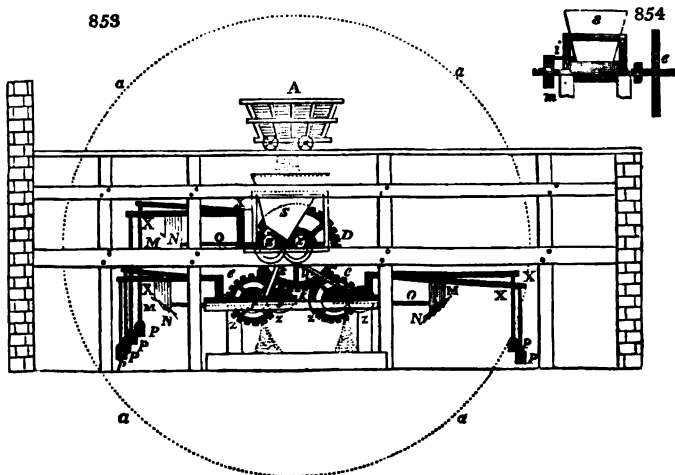
The apparatus subservient to grinding the ore are, —

1. The *bucker*, or beater, formed of a cast-iron plate, 3 inches square, with a socket in its upper surface, for receiving a wooden handle. In the neighbourhood of Alston Moor, crushing cylinders have been substituted for the beating buckler; but even now, in Derbyshire, buckers are generally employed for breaking the pieces of mixed ore, called *knock-stone-stuff*.

At the mines of this county, the *knocker's workshop*, or *striking floor*, is provided either with a strong stool, or a wall 3 feet high, beyond which there is a flat area 4 feet broad, and a little raised behind. On this area, bounded, except in front, by small walls, the ore to be bruised is placed. On the stool, or wall, a very hard stone slab, or cast-iron plate is laid, 7 feet long, 7 inches broad, and $1\frac{1}{2}$ inches thick, called a *knock-stone*. The workmen seated before it break the pieces of mixed ore, called *bouse* in Derbyshire, with the buckler.

Crushing machines are in general use at Alston Moor, to break the mingled ores, which they perform with great economy of time and labour. They have been employed there for upwards of fifty years.

This machine is composed of one pair of fluted cylinders, $x x$, *fig. 853*, and of two pairs of smooth cylinders $z z$, $z' z'$, which serve altogether for crushing the ore. The two cylinders of each of the three pairs turn simultaneously in an inverse direction, by means of two toothed wheels, as at *m, fig. 854*, upon the shaft of every cylinder, which



work by pairs in one another. The motion is given by a single water wheel, of which the circle $a a a$ represents the outer circumference. One of the fluted cylinders is placed in the prolongation of the shaft of this wheel, which carries besides a cast-iron toothed wheel, geared with the toothed wheels $e e$, fixed upon the ends of two of the smooth cylinders. Above the fluted cylinders there is a hopper, which discharges down between them, by means of a particular mechanism, the ore brought forward by the waggons *A*. These waggons advance upon a railway, stop above the hopper, and empty their contents into it through a trap-hole, which opens outwardly in the middle

of their bottom. Below the hopper there is a small bucket called a shoe, into which the ore is shaken down, and which throws it without ceasing upon the cylinders, in consequence of the constant jolts given it by a crank-rod *i* (*fig. 854.*) attached to it, and moved by the teeth of the wheel *m*. The shoe is so regulated, that too much ore can never fall upon the cylinders, and obstruct their movement. A small stream of water is likewise led into the shoe, which spreads over the cylinders, and prevents them from growing hot. The ore, after passing between the fluted rollers, falls upon the inclined planes *n, n*, which turn it over to one or other of the pairs of smooth rolls.

These are the essential parts of this machine; they are made of iron, and the smooth ones are case-hardened, or *chilled*, by being cast in iron moulds. The gudgeons of both kinds move in brass bushes fixed upon iron supports *k*, made fast by bolts to the strong wood-work basis of the whole machine. Each of the horizontal bars has an oblong slot, at one of whose ends is solidly fixed one of the plummer-blocks or bearers of one of the cylinders *f*, and in the rest of the slot the plummer-block of the other cylinder *g* slides; a construction which permits the two cylinders to come into contact, or to recede to such a distance from each other, as circumstances may require. The movable cylinder is approximated to the fixed one by means of the iron levers *x, x*, which carry at their ends the weights *r*, and rest upon wedges *n*, which may be slid upon the inclined plane *n*. These wedges then press the iron bar *o*, and make it approach the movable cylinder by advancing the plummer-block which supports its axis. When matters are so arranged, should a very large or hard piece present itself to one of the pairs of cylinders, one of the rollers would move away, and let the piece pass without doing injury to the mechanism.

Besides the three pairs of cylinders which constitute essentially each crushing machine, there is sometimes a fourth, which serves to crush the ore when not in large fragments, for example, the *chats* and *cuttings* (the moderately rich and poorer pieces), produced by the first sifting with the brake sieve, to be presently described. The cylinders composing that accessory piece, which, on account of their ordinary use, are called *chats-rollers*, are smooth, and similar to the rollers *z z* and *x' x'*. The one of them is usually placed upon the prolongation of the shaft of the water-wheel, of the side opposite to the principal machine; and the other, which is placed alongside, receives its motion from the first, by means of toothed wheel-work.

The *stamp mill* is employed in concurrence with the crushing cylinders. It serves particularly to pulverize those ores whose gangue is too hard to yield readily to the rollers, and also those which being already pulverized to a certain degree require to be ground still more finely. The stamps employed in the neighbourhood of Alston Moor are moved by water wheels. They are similar to those described under **IX**.

Proper sifting or jigging apparatus.—The hand sieve made of iron wire meshes, of various sizes, is shaken with the two hands in a tub of water, the *ore cat* being held sometimes horizontally, and at others in an inclined position. This sieve is now in general use only for the *cuttings* that have passed through the grating, and which though not poor enough to require finer grinding, are too poor for the brake sieve. When the workman has collected a sufficient quantity of these smaller pieces, he puts them in his round hand sieve, shakes it in the ore vat with much rapidity and a dexterous toss, till he has separated the very poor portions called *cuttings*, from the mingled parts called *chats*, as well as from the pure ore. He then removes the first two qualities, with a sheet-iron scraper called a *limp*, and he finds beneath them a certain portion of ore which he reckons to be pure.

The *brake sieve* is rectangular, as well as the cistern in which it is agitated. The meshes are made of strong iron wire, three-eighths of an inch square. This sieve is suspended at the extremity of a forked lever, or brake, turning upon an axis by means of two upright arms about 5 feet long, which are pierced with holes for connecting them with bolts or pins, both to the sieve-frame and to the ends of the two branches of the lever. These two arms are made of wrought iron, but the lever is made of wood; as it receives the jolt. A child placed near its end, by the action of leaping, jerks it smartly up and down, so as to shake effectually the sieve suspended at the other extremity. Each jolt not only makes the fine parts pass through the meshes, but changes the relative position of those which remain on the wires, bringing the purer and heavier pieces eventually to the bottom. The mingled fragments of galena, and the stony substances called *chats*, lie above them; while the poor and light pieces, called *cuttings*, are at top. These are first scraped off by the *limp*, next the mixed lumps, or *chats*, and lastly the pure ore, which is carried to the *bing heap*. The *cuttings* are handed to a particular class of workmen, who by a new sifting divide them into mere stones, or second *cuttings*, and into mixed ore analogous to *chats*.

The poor ore, called *chats*, is carried to a crushing machine, where it is bruised between two cylinders appropriated to this purpose under the name of *chats rollers*; after which it is sifted afresh. During the sifting many parcels of small ore and stony sub-

stances pass through the sieve, and accumulate at the bottom of the cistern. When it is two thirds filled, water is run slowly over it, and the sediment called *smitham* is taken out, and piled up in heaps. More being put into the tub, a child lifts up the *smitham*, and lays it on the sieve, which retains still on its meshes the layer of fine ore. The *sifter* now agitates in the water nearly as at first, from time to time removing with the *limp* the lighter matters as they come to the surface; which being fit for washing only in boxes, are called *buddler's offal*, and are thrown into the *buddle hole*.

Mr. Petherick, the manager of Lanesoot and the Fowey Consol mines, has contrived an ingenious jiggng machine, in which a series of 8 sieves are fixed in a stationary circular frame, connected with a plunger or piston working in a hollow cylinder, whereby a body of water is alternately forced up through the crushed ore in the sieves, and then left to descend. In this way of operating, the indiscriminate or premature passage of the finer pulverulent matter through the meshes is avoided, because a regulated stream of water is made to traverse the particles up and down. This mode has proved profitable in washing the copper ores of the above mentioned copper mines.

Proper washing apparatus. — For washing the ore after sifting it, the running buddle already described is employed, along with several chests or *buddles* of other kinds.

1. The *trunk buddle* is a species of German chest (see METALLURGY and TIN) composed of two parts; of a cistern or box into which a stream of water flows, and of a large tank with a smooth level bottom. The ore to be *trunked* being placed in the box, the workman furnished with a shovel bent up at its sides agitates it, and removes from time to time the coarser portions; while the smaller are swept off by the water and deposited upon the level area.

2. The *stirring buddle*, or chest for freeing the *schlamms* or slimy stuff from clay, is analogous to the German chests, and consists of two parts; namely, 1. a trough which receives a stream of water through a plug hole, which is tempered at pleasure, to admit a greater or less current; 2. a settling tank with a horizontal bottom. The metallic *slime* being first floated in the water of the trough, then flows out and is deposited in the tank; the purest parts falling first near the beginning of the run.

3. The *nicking buddle*, is analogous to the tables called *dormantes* or *jumelles* by the French miners. See METALLURGY. They have at their upper end a cross canal or spout, equal in length to the breadth of the table, with a plug hole in its middle for admitting the water. Alongside of this channel there is a slightly inclined plank, called *nicking board*, corresponding to the head of the *twin table*, and there is a nearly level plane below. The operation consists in spreading a thin layer of the *slime* upon the *nicking board*, and in running over its surface a slender sheet of water, which in its progress is subdivided into rills, which gradually carry off the muddy matters, and strew them over the lower flat surface of the tank, in the order of their density.

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4. The *dolly tub* or rinsing bucket, *fig. 855.*, has an upright shaft which bears the vane or *dolly* Δ , turned by the winch handle. This apparatus serves to bring into a state of suspension in water the fine ore, already nearly pure; the separation of the metallic particles from the earthy ones by repose being promoted by the sides of the tub being struck frequently during the subsidence.

5. *Slime pits.* — In the several operations of cleansing ores from mud, in grinding, and washing, where a stream of water is used, it is impossible to prevent some of the finely attenuated portions of the galena, called *sludge*, floating in the water, from being carried off with it. *Slime pits* or *labyrinths* called *buddle holes* in Derbyshire, are employed to collect that matter, by receiving the water to settle, at a little distance from the place of agitation.

These basins or reservoirs are about 20 feet in diameter, and from 24 to 40 inches deep. Here the suspended ore is deposited, and nothing but clear water is allowed to escape.

The workmen employed in the mechanical preparation of the ores are paid, in Cumberland, by the piece, and not by day's wages. A certain quantity of crude ore is delivered to them, and their work is valued by the *bing*, a measure containing 14 cwt. of ore ready for smelting. The price varies according to the richness of the ore. Certain qualities are washed at the rate of two and sixpence, or three shillings the *bing*; while others are worth at least ten shillings. The richness of the ore varies from 2 to 20 *bing*s of galena per *shift* of ore; the *shift* corresponding to 8 waggons load.

1. The cleansing and sorting of the ores are well performed in Cumberland. These operations seem however to be inferior to the cleansing on the *grid steps*, *grilles à gradins*, of Saxony (see METALLURGY), an apparatus which in cleaning the ores has the advantage of grouping them in lots of different qualities and dimensions.

2. The breaking or bruising by means of the *crushing machine*, is much more expeditious than the Derbyshire process by *buckers*; for the machine introduces not only great economy into the breaking operation, but it likewise diminishes considerably the loss of galena; for stamped ores may be often subjected to the action of the cylinders

without waste, while a portion of them would have been lost with the water that runs from the stamp mill. The use of these rollers may therefore be considered as one of the happiest innovations hitherto made in the mechanical preparation of ores.

3. The *brake sieves* appear to be preferable to the hand ones.

4. The system of washing used in Cumberland differs essentially from that of Brittany. The slime pits are constructed with much less care than in France and Germany. They never present, as in these countries, those long windings backwards and forwards, whence they have been called labyrinths; probably because the last deposits, which are washed with profit in France and Germany, could not be so in Cumberland. There is reason to believe, however, that the introduction of *brake tables*, (*tables à secousses*, see METALLURGY) would enable deposits to be saved, which at present run to waste in England.

5. From what we have now said about the system of washing, and the basins of deposit or settling cisterns, it may be inferred that the operation followed in Cumberland is more expeditious than that used in Brittany, but it furnishes less pure ores, and occasions more considerable waste; a fact sufficiently obvious, since the refuse stuff at Poulläouen is often resumed, and profitably subjected to a new preparation. We cannot however venture to blame this method, because in England, fuel being cheap, and labour dear, there may possibly be more advantage in smelting an ore somewhat impure, and in losing a little galena, than in multiplying the number of washing processes.

6. Lastly, the *dolly tub* ought to be adopted in all the establishments where the galena is mixed with much blende (sulphuret of zinc); for *schlich* (metallic slime) which appears very clean to the eye, gives off a considerable quantity of blende by means of the *dolly tub*. While the vane is rapidly whirled, the sludge is gradually let down into the revolving water, till the quantity is sufficiently great. Whenever the ore is thoroughly disseminated in the liquid, the dolly is withdrawn. The workmen then strike on the sides of the tub for a considerable time, with mallets or wooden billets, to make the slime fall fast to the bottom. The lighter portions, consisting almost entirely of refuse matter, fall only after the knocking has ceased; the water is now run away; then the very poor slime upon the top of the deposit is skimmed off; while the pure ore found at the bottom of the tub is lifted out, and laid on the *dingstead*. In this way the blende, which always accompanies galena in a greater or smaller quantity, is well separated.

Smelting of lead ores.—The lead ores of Derbyshire and the north of England were anciently smelted in very rude furnaces, or *boles*, urged by the natural force of the wind, and were therefore placed on the summits or western slopes of the highest hills. More recently these furnaces were replaced by blast hearths, resembling smiths' forges, but larger; and were blown by strong bellows, moved by men or water-wheels. The principal operation of smelting is at present always executed in Derbyshire in *reverberatory furnaces*, and at Alston Moor in furnaces similar to those known in France by the name of Scotch furnaces. Before entering into the detail of the founding processes, we shall give a description of the furnaces essential for both the smelting and accessory operations.

1. The reverberatory furnace called cupola, now exclusively used in Derbyshire for the smelting of lead ores, was imported thither from Wales, about the year 1747, by a company of Quakers. The first establishment in this county was built at Kalstedge, in the district of Ashover.

In the works where the construction of these furnaces is most improved, they are interiorly 8 feet long by 6 wide in the middle, and 2 feet high at the centre. The fire, placed at one of the extremities, is separated from the body of the furnace by a body of masonry, called the *fire-bridge*, which is 2 feet thick, leaving only from 14 to 18 inches between its upper surface and the vault. From this, the highest point, the vault gradually sinks towards the further end, where it stands only 6 inches above the sole. At this extremity of the furnace, there are two openings separated by a triangular prism of *fire-stone*, which lead to a flue, a foot and a half wide, and 10 feet long, which is recurved towards the top, and runs into an upright chimney 55 feet high. The above flue is covered with stone slabs, carefully jointed with fire-clay, which may be removed when the deposit formed under them (which is apt to melt) requires to be cleaned out. One of the sides of the furnace is called the labourers' side. It has a door for throwing coal upon the fire-grate, besides three small apertures each about 6 inches square. These are closed with movable plates of cast-iron, which are taken off when the working requires a freer circulation of air, or for the stirring up of the materials upon the hearth. On the opposite side, called the working side, there are five apertures; namely, three equal and opposite to those just described, shutting in like manner with cast-iron plates, and beneath them two other openings, one of which is for running out the lead, and another for the scoriae. The ash pit is also on this side, covered with a little water, and so disposed as that the grate-bars may be easily cleared from the cinder slag.

The hearth of the furnace is composed of the reverberatory furnace slags, to which a

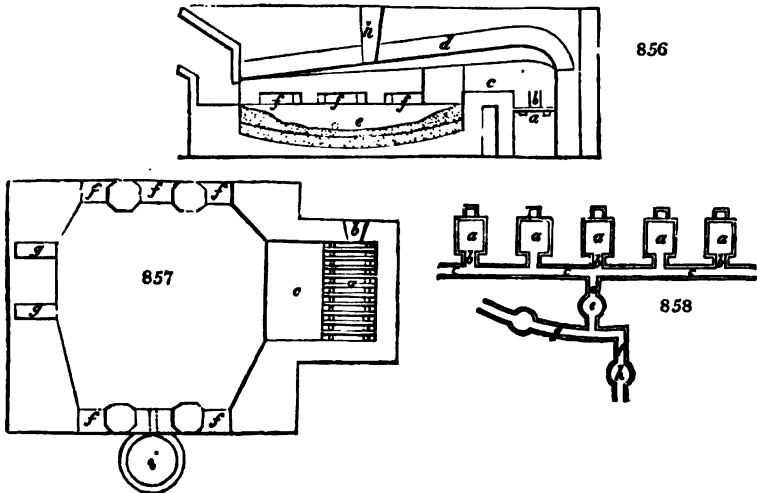
proper shape has been given by beating them with a strong iron rake, before their entire solidification. On the labourer's side, this hearth rises nearly to the surface of the three openings, and falls towards the working side, so as to be 18 inches below the middle aperture. In this point, the lowest of the furnace, there is a tap-hole, through which the lead is run off into a large iron boiler (lea-pan), placed in a recess left outside in the masonry. From that lowest point, the sole gradually rises in all directions, forming thus an inside basin, into which the lead runs down as it is smelted. At the usual level of the metal bath, there is on the working side, at the end furthest from the fire, an aperture for letting off the slag.

In the middle of the arched roof there is a small aperture, called the *cross-hole*, which is covered up during the working with a thick cast-iron plate. Above this aperture a large wooden or iron hopper stands, leading beneath into an iron cylinder, through which the contents of the hopper may fall into the furnace when a trap or valve is opened.

2. *The roasting furnace.*— This was introduced about 30 years ago, in the neighbourhood of Alston Moor, for roasting the ore intended to pass through the Scotch furnace, a process which greatly facilitates that operation. Since its first establishment it has successively received considerable improvements.

Figs. 856, 857, 858., represent the cupola furnace at the Marquess of Westminster's lead smelting works, two miles from Holywell. The hearth is hollowed out below the middle door of the furnace; it slopes from the back and ends towards this basin. The distance from the lowest point of this concavity up to the sill of the door, is usually 24 inches, but it is sometimes a little less, according to the quality of the ores to be smelted. This furnace has no hole for running off the slag, above the level of the top hole for the lead *i*, like the smelting furnace of Lea, near Matlock. A single chimney stalk serves for all the establishments; and receives all the flues of the various roasting and reducing furnaces. *Fig. 858.* gives an idea of the distribution of these flues. *a a a*, &c. are the furnaces; *b*, the flues, 18 inches square; these lead from each furnace to the principal conduit *c*, which is 5 feet deep by 2½ wide; *d* is 6 feet deep by 3 wide; *e* is a round chamber 15 feet in diameter; *f* is a conduit 7 feet high by 5 wide; *g* another, 6 feet high by 3 wide. The chimney at *h* has a diameter at bottom of 30 feet, at top of 12 feet, including the thickness of its sides, forming a truncated cone 100 feet high; whose base stands upon a hill a little way from the furnaces, and 62 feet above their level.

a, *figs. 856, 857.*, is the grate; *b*, the door of the fire-place; *c*, the fire-bridge; *d*, the



arched roof; *e*, the hearth; *fff*, &c., the working doors; *gg*, flues running into one conduit, which leads to the subterranean condensing-chamber *e*, and thence to the general chimney; *h*, a hopper-shaped opening in the top of the furnace, for supplying it with materials.

This magnificent structure is not destined solely for the reduction of the ores, but for dissipating all the vapours which might prove noxious to the health of the workpeople and to vegetation.

The ores smelted at Holywell are very refractory galenas, mixed with blende, calamine,

pyrites, carbonate of lime, &c., but without any fluete of lime. They serve mutually as fluxes to one another. The coal is of inferior quality. The sole of each furnace is formed of slags obtained in the smelting, and they are all of one kind. In constructing it, 7 or 8 tons of these slags are first of all thrown upon the brick area of the hearth; are made to melt by a brisk fire, and in their stiffening state, as they cool, they permit the bottom to be sloped and hollowed into the desired shape. Four workmen, two at each side of the furnace, perform this task.

The ordinary charge of ore for one smelting operation is 20 cwt., and it is introduced through the hopper; see *COPPER*, *fig.* 375. An assistant placed at the back doors spreads it equally over the whole hearth with a rake; the furnace being meanwhile heated only with the declining fire of a preceding operation. No regular fire is made during the first two hours, but a gentle heat merely is kept up by throwing one or two shovelfuls of small coal upon the grate from time to time. All the doors are closed, and the register-plate of the chimney is lowered.

The outer basin in front of the furnace is at this time filled with the lead derived from a former process, the metal being covered with slags. A rectangular slit above the tap hole is left open, and remains so during the whole time of the operation, unless the lead should rise in the interior basin above the level of that orifice; in which case a little mound must be raised before it.

The two doors in front furthest from the fire being soon opened, the head-smelter throws in through them, upon the sole of the furnace, the slags swimming upon the bath of lead, and a little while afterwards he opens the tap-hole, and runs off the metallic lead reduced from these slags. At the same time his assistant turns over the ore with his paddle, through the back doors. These being again closed, while the above two front doors are open, the smelter throws a shovelful of small coal or coke cinder upon the lead bath, and works the whole together, turning over the ore with the paddle or iron oar. About three quarters of an hour after the commencement of the operation, he throws back upon the sole of the hearth the fresh slags which then float upon the bath of the outer basin, and which are mixed with coaly matter. He next turns over these slags, as well as the ore with the paddle, and shuts all the doors. At this time the smelter runs off the lead into the pig-moulds.

The assistant now turns over the ore once more through the back doors. A little more than an hour after the operation began, a quantity of lead proceeding from the slag last remelted, is run off by the tap; being usually in such quantity as to fill one half of the outer basin. Both the workmen then turn over the ore with the paddles, at the several doors of the furnace. Its interior is at this time of a dull red heat; the roasting being carried on rather by the combustion of the sulphurous ingredients, than by the action of the small quantity of coal in the grate. The smelter, after shutting the front doors, with the exception of that next the fire-bridge, lifts off the fresh slags lying upon the surface of the outside bath, drains them, and throws them back into the furnace.

An hour and a half after the commencement, the lead begins to ooze out in small quantities from the ore; but little should be suffered to flow before two hours have expired. About this time the two workmen open all the doors, and turn over the ore, each at his own side of the furnace. An hour and three quarters after the beginning, there are few vapours in the furnace, its temperature being very moderate. No more lead is then seen to flow upon the sloping hearth. A little coal being thrown into the grate to raise the heat slightly, the workmen turn over the ore, and then close all the doors.

At the end of two hours, the *first fire* or roasting being completed, and the doors shut, the register is to be lifted a little, and coal thrown upon the grate to give the *second fire*, which lasts during 25 minutes. When the doors are now opened, the inside of the furnace is of a pretty vivid red, and the lead flows down from every side towards the inner basin. The smelter with his rake or paddle pushes the slags upon that basin back towards the upper part of the sole, and his assistant spreads them uniformly over the surface through the back doors. The smelter next throws in by his middle door, a few shovelfuls of quicklime upon the lead bath. The assistant meanwhile for a quarter of an hour works the ore and the slags together through the three back doors, and then spreads them out, while the smelter pushes the slags from the surface of the inner basin back to the upper parts of the sole. The doors being now left open for a little, while the interior remains in repose, the metallic lead, which had been pushed back with the slags, flows down into the basin. This occasional *cooling* of the furnace is thought to be necessary for the better separation of the products, especially of the slags from the lead bath.

In a short time the workmen resume their rakes, and turn over the slags along with the ore. Three hours after the commencement, a little more fuel is put into the grate, merely to keep up a moderate heat of the furnace during the paddling. After three

hours and ten minutes, the grate being charged with fuel for the *third fire*, the register is completely opened, the doors are all shut, and the furnace is left in this state for three quarters of an hour. In nearly four hours from the commencement, all the doors being opened, the assistant levels the surfaces with his rake, in order to favour the descent of any drops of lead; and then spreads the slags, which are pushed back towards him by the smelter. The latter now throws in a fresh quantity of lime, with the view not merely of covering the lead bath and preventing its oxidizement, but of rendering the slags less fluid.

Ten minutes after the third fire is completed, the smelter puts a new charge of fuel in the grate, and shuts the doors of the furnace to give it the *fourth fire*. In four hours and forty minutes from the commencement, this fire being finished, the doors are opened, the smelter pierces the tap-hole to discharge the lead into the outer basin, and throws some quicklime upon the slags in the inner basin. He then pushes the slags thus *dried up* towards the upper part of the hearth, and his assistant rakes them out by the back doors.

The whole operation of a *smelting shift* takes about four hours and a half, or at most five hours, in which four periods may be distinguished.

1. The *first fire* for roasting the ores requires very moderate firing, and lasts two hours.

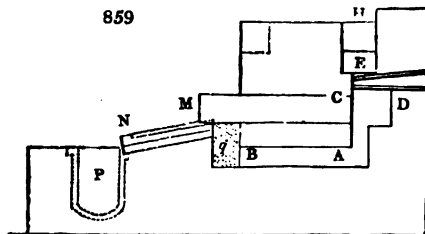
2. The *second fire*, or the smelting, requires a higher heat, with shut doors; at the end the slags are *dried up* with lime, and the furnace is also allowed to cool a little.

3, 4. The last two periods, or the *third and fourth fires*, are likewise two smeltings or foundings, and differ from the first only in requiring a higher temperature. The heat is greatest in the last. The form and dimensions of the furnace are calculated to cause a uniform distribution of heat over the whole surface of the hearth. Sometimes billets of green wood are plunged into the metallic lead of the outer basin, causing an ebullition which favours the separation of the slags, and consequently the production of a purer lead; but no more metallic metal is obtained.

Ten cwt. of coal are consumed at Holywell in smelting one ton of the lead-ore *schlich* or sludge; but at Grassington, near Skipton in Yorkshire, with a similar furnace worked with a slower heat, the operation taking from seven hours to seven hours and a half, instead of five, only $7\frac{1}{2}$ cwt. of coal are consumed. But here the ores are less refractory, have the benefit of fluor spar as a flux, and are more exhausted of their metal, being smelted upon a less sloping hearth.

Theory of the above operations. — At Holywell, Grassington, and in Cornwall, the result of the first graduated roasting heat, is a mixture of undecomposed sulphuret of lead, with sulphate and oxide of lead, in proportions which vary with the degree of care bestowed upon the process. After the roasting, the heat is raised to convert the sludge into a pasty mass; in which the oxide and sulphate react upon the sulphuret, so as to produce a sub-sulphuret, which parts with the metal by liquation. The *cooling of the furnace* facilitates the liquation every time that the sub-sulphuret is formed, and the ore has passed by increase of temperature from the pasty into the liquid state. *Cooling* brings back the sludge to the pasty condition, and is therefore necessary for the due separation of the different bodies. The drying up of the thin slags by lime is intended to liberate the oxide of lead, and allow it to react upon any sulphuret which may have resisted roasting or decomposition. It is also useful as a *thickener*, in a mechanical point of view. The iron of the tools, which wear away very fast, is also serviceable in reducing the sulphuret of lead. The small coal added along with the lime at Grassington, and also sometimes at Holywell, aids in reducing the oxide of lead, and in transforming the sulphate into sulphuret.

3. *The smelting furnace or ore hearth.* — This furnace, called by the French *écossais*, is from 22 to 24 inches in height and 1 foot by $1\frac{1}{4}$ in area inside; but its horizontal section, always rectangular, varies much in its dimensions at different levels, as shown in *fig.* 859.



The hearth and the sides are of cast iron; the sole-plate λ is also of cast iron, 2½ inches thick, having on its back and two sides an upright ledge, α c, 2½ inches thick, and 4½ high. In front of the hearth there is another cast iron plate m x , called the *work-stone*, surrounded on every side excepting towards the sole of the furnace, by a ledge one inch in thickness and height. The plate slopes from behind forwards, and its posterior ledge, which is about 4½ inches above the surface of the hearth, is separated from it by a void space g , which is filled with a mixture of bone ash and galena, both in fine powder, moistened and pressed down together. The melted lead cannot penetrate into this body, but after filling the basin at the bottom of the furnace, flows naturally out by the gutter (nearly an inch deep) through a groove in the *work-stone*; and then passes into a cauldron of reception r , styled the *melting-pot*, placed below the front edge of the *work-stone*.

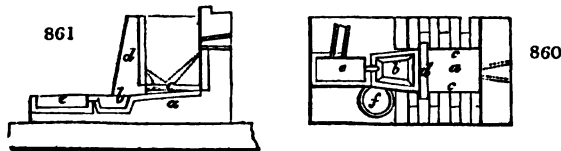
The posterior ledge of the sole is surmounted by a piece of cast iron c d , called the *back-stone*, 28 inches long, and 6½ high; on which the *tuyère* or blast-pipe is placed. It supports another piece of cast iron x , called *pipe-stone*, scooped out at its under part, in the middle of its length, for the passage of the *tuyère*. This piece advances 2 inches into the interior of the furnace, the back wall of which is finally crowned by another piece of cast iron x β , called also *back-stone*.

On the ledges of the two sides of the sole are placed two pieces of cast iron, called *bearers*, each of which is 5 inches in breadth and height, and 26 inches long. They advance an inch or two above the posterior and highest edge of the *work-stone* and contribute effectually to fix it solidly in its place. These bearers support, through the intervention of several ranges of fire-bricks, a piece of cast iron called a *fore-stone*, which has the same dimensions as the piece called the *back-stone*, on which the base of the blowing-machine rests. This piece is in contact, at each of its extremities, with another mass of cast iron, 6 inches cube, called the *key-stone*, supported on the masonry. Lastly, the void spaces left between the two *key-stones* and the back part of the furnace are filled up with two masses of cast iron exactly like the *key-stones*.

The front of the furnace is open for about 12 inches from the lower part of the front cross-piece called *fore-stone*, up to the superior part of the *work-stone*. It is through this opening that the smelter operates.

The gaseous products of the combustion, on escaping from this ore hearth, are frequently made to pass through a long flue, sloped very slightly upwards, in which they deposit all the particles of ore that they may have swept along; these flues, whose length is sometimes more than 100 yards, are usually 5 feet high and 3 feet wide in the inside, and always terminate in a chimney stalk. The matters deposited near the commencement of the flue require to be washed; but not the other dusty deposits. The whole may then be carried back to the roasting furnace, to be calcined and re-agglutinated, or introduced without any preparation into the *slag hearth*.

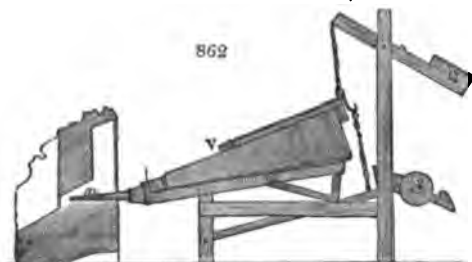
4. Figs. 860, 861 represent a slag-hearth, the *fourneau à manche* (elbow furnace) of the



French, and the *krummofen* (crooked furnace) of the Germans; such as is used at Alston Moor, in Cumberland, for the reduction of the lead-slag. It resembles the Scotch furnace. The shaft is a parallelepiped, whose base is 26 inches by 22 in area inside, and whose height is 3 feet; the sole-plate a , of cast iron, slopes slightly down to the basin of reception, or the fore-hearth b . Upon both of the long sides of the sole-plate there are cast iron beams, called *bearers*, c c , of great strength, which support the side walls built of a coarse grained sandstone, as well as the cast iron plate d (*fore-stone*), which forms the front of the shaft. This stands 7 inches off from the sole-plate, leaving an empty space between them. The back side is made of cast iron, from the sole-plate to the horizontal *tuyère* in its middle; but above this point it is made of sandstone. The *tuyère* is from 1½ to 2 inches in diameter. In front of the fore-hearth b , a cistern e is placed, through which water continually flows, so that the slags which spontaneously overflow the fore-hearth may become inflated and shattered, whereby the lead disseminated through them may be readily separated by washing. The lead itself flows from the fore-hearth b , through an orifice, into an iron pot f , which is kept hot over a fire. The metal obtained from this slag-hearth is much less pure than that extracted directly from the ore.

The whole bottom of the furnace is filled to a height of 17 inches, that is, to within 2 or 3 inches of the tuyère, with the rubbish of coke reduced to coarse powder and beat strongly down. At each *smelting shift*, this bed must be made anew, and the interior of the furnace above the tuyère repaired, with the exception of the front, consisting of cast iron. In advance of the furnace there is a basin of reception, which is also filled with coke rubbish. Farther off is a pit, full of water, replenished by a cold stream, which incessantly runs in through a pipe. The scoriae, in flowing out of the furnace, pass over the coke bed in the basin of reception, and then fall into the water, whose coolness makes them fly into small pieces, after which they are easily washed, so as to separate the lead that may be entangled among them.

These furnaces are urged, in general, by wooden bellows, *fig. 862*. But at the smelting



works of Lea, near Matlock, the blowing-machine consists of two casks, which move upon horizontal axes. Each of these casks is divided into two equal parts by a fixed plane that passes through its axis, and is filled with water to a certain height. The water of one side communicates with that of the other by an opening in the lower part of the division. Each cask possesses a movement of oscillation, produced by a rod attached to a crank of a bucket-wheel. At each demi-oscillation, one of the compartments, being in communication with the external air, is filled; whilst the other, on the contrary, communicates with the nozzle, and supplies wind to the furnace.

5. *Refining or cupellation furnace.* See SILVER.

6. *Smelting by the reverberatory furnace*, is adopted exclusively in Derbyshire, and in some works at Alston Moor. The charge in the hopper consists commonly of 16 cwt., each weighing 120 lbs. avoirdupois, composed of an intimate mixture of 5, 6, 7 or even 8 kinds of ore, derived from different mines, and prepared in different ways. The proportions of the mixture are determined by experience, and are of great consequence to the success of the work.

The ore is rather in the form of grains than of a fine *schlick*; it is sometimes very pure, and affords 75 per cent.; but usually it is mixed up with a large proportion of carbonate and fluete of lime; and its product varies from 65 to 23 per cent.

After scraping the slaggy matters out of the furnace, a fresh smelting shift is introduced at an interval of a few minutes; and thus, by means of two alternate workmen, who relieve each other every seven or eight hours, the weekly operations continue without interruption. The average product in lead of the reverberatory furnaces in Derbyshire, during several years, has been 66 per cent. of the ore. Very fine ore has, however, afforded 76.

7. *Smelting of the drawn slag, on the slag-mill hearth.*—The black slag of the reverberatory furnace is broken by hammers into small pieces, and mixed in proper proportions with the coal cinders that fall through the grate of the reverberatory fire. The leaden *matts* that float on the surface of the bath, and the dust deposited in the chimney, are added, along with some poor ore containing a gangue of fluor spar and limestone, which had been put aside during the mechanical preparation. With such a mixture, the slag-hearth, already described, *figs. 860, 861*, is charged. By the action of heat and coal, the lead is revived, the earthy matters flow into very liquid scoriae, and the whole is made to pass across the body of fire into a basin of reception placed beneath. The scoriae are thickened by throwing quicklime upon them, and they are then raked away. At the end of the operation the lead is cast into pigs or ingots of a peculiar form. This is called slag-lead. It is harder, more sonorous than the lead obtained from the reverberatory furnace, and is preferred for the manufacture of minium, lead shot, and some other purposes.

8. *Treatment of lead ores by the Scotch furnace or ore-hearth.*—This furnace is generally employed in the counties of Northumberland, Cumberland, and Durham, for the smelting of lead ores, which were formerly carried to them without any preparation,

but now they are exposed to a preliminary calcination. The roasted ore yields in the Scotch furnace a more considerable product than the crude ore, because it forms in the furnace a more porous mass, and at the same time it *works drier*, to use the founder's expression; that is, it allows the stream of air impelled by the bellows to diffuse itself more completely across the matters contained in the furnace.

The charge of the *roasting furnace*, *fig. 856, 857, 858.*, is from 9 to 11 cwt. of ore, put into the furnace without any addition. Three such shifts are usually passed through in eight hours. The fire should be urged in such a manner as to produce constantly a dense smoke, without letting any part of the ore melt and form a slag; an accident which would obstruct the principal end of the process, which is to burn off the sulphur and antimony, and to expel the carbonic acid of the carbonate of lead. The ore must be frequently turned over, by moving it from the bridge to the other end and back again. To prevent the ore from running into masses as it cools, it is made to fall out of the furnace into a pit full of water, placed below one of the lateral doors.

Smelting of the lead ores in the Scotch furnace. — When a *smelting shift* has been finished in the Scotch furnace, a portion of the ore, called *browse*, remains in a semi-reduced state, mixed with coke and cinders. It is found of more advantage to preserve the browse for beginning the following operation, than to take raw or even roasted ore. To set the furnace in action, the interior of it is filled with peats, cut into the form of bricks. The peats towards the posterior part are heaped up without order, but those near the front are piled up with care in the form of a wall. A kindled peat is now placed before the nozzle of the bellows, which are made to blow, and the blast spreads the combustion rapidly through the whole mass. To increase the heat, and to render the fire more steady and durable, a few shovelfuls of coals are thrown over the turf. A certain quantity of the browse is to be next introduced; and then (or sometimes before all the browse is put in) the greater part of the matters contained in the furnace is drawn over on the *work-stone*, by means of a large rake called a *gowelock*; the refuse of the ore called *gray slag*, which a skilful smelter knows by its shining more than the browse, is taken off with a shovel, and thrown to the right hand into a corner outside of the furnace. The browse left on the work-stone is to be now thrown back into the furnace, with the addition of a little coal, if necessary. If the browse be not well cleaned from the slag, which is perceived by the whole mass being in a soft state, and showing a tendency to fuse, quicklime must be added, which by its affinity for the argillaceous, siliceous, and ferruginous substances, dries up the materials, as the smelters say, and gives to the earthy parts the property of concreting into lumps or balls; but if, on the other hand, the siliceous, argillaceous, or ferruginous parts contained in the ore be too refractory, lime is also to be added, but in smaller quantity, which by rendering them more fusible, communicates the property of concreting into balls. These lumps, called *gray slag*, contain from one-tenth to one-fifteenth of the lead which was present in the ore. They must be smelted afterwards at a higher temperature in the slag hearth, to extract their lead. After the browse has been thrown back into the furnace, as has been said, a few shovelfuls of ore are to be strewed over it; but before doing this, and after removing the scoriae, there must be always placed before the tuyère half a peat, a substance which, being extremely porous and combustible, not only hinders any thing from entering the nozzle of the bellows, but spreads the blast through all the vacant parts of the furnace. After an interval of from 10 to 15 minutes, according to circumstances, the materials in the furnace are drawn afresh upon the work-stone, and the gray slag is removed by the rake. Another peat being placed before the tuyère, and coal and quicklime being introduced in suitable proportions, the browse is thrown back into the furnace, a fresh portion of ore is charged above it, and left in the furnace for the above mentioned time.

This mode of working, continued for 14 or 15 hours, forms what is called a *smelting shift*; in which time from 20 to 40 cwt. of lead, and even more, are produced.

By this process the purest part of the lead, as well as the silver, are sweated out, as it were, from the materials with which they are mixed, without any thing entering into fusion except these two metals in the state of alloy. It is probable that the moderate temperature employed in the Scotch furnace is the main cause of the purity of the lead which it yields.

9. *Smelting of the scoriae of the Scotch furnace on the slag hearth.* — Before putting fire to the slag hearth already described, *figs. 635, 636.*, its empty space is to be filled with peats, and a lighted one being placed before the tuyère, the bellows are made to play. A layer of coke is to be now thrown upon the burning peats, and as soon as the heat is sufficiently high, a layer of the *gray slag* is to be introduced, or of any other scoriae that are to be reduced. From time to time, as the fit moment arrives, alternate strata of coke and slag are to be added. In this operation, though the slag and the lead are brought to a state of perfect fluidity, the metal gets separated by filtering down through

the bed of peat cinders, which the slag cannot do on account of its viscosity. Whenever that coke bed becomes covered with fluid slag, the workman makes a hole in it, of about an inch diameter, by means of a kneed poker; and runs it off by this orifice, as it cannot sink down into the hard rammed cinders, which fill the basin of reception. The slag flows over it in a glowing stream into the pit filled with water, where it gets granulated and ready for washing.

When lead is obtained from galena without the addition of combustible matter, we have an example on the great scale of the mutual decomposition of the oxides and sulphates formed during the roasting heat, by the still undecomposed galena, especially when this action is facilitated by working up and skilfully mingling the various matters, as happens in the reverberatory and Scotch furnaces. It is therefore the sulphuret of lead itself which serves as the agent of reduction in regard to the oxide and sulphate, when little or no charcoal has been added. Sometimes, however, towards the end of the operation in the reverberatory hearth, it becomes necessary to throw in some wood or charcoal, because the oxidisement having become too complete, there does not remain a sufficient body of sulphuret of lead to effect the decompositions and reductions just mentioned, and therefore it is requisite to regenerate some galena by means of carbonaceous matter, which immediately converts the sulphate of lead into the sulphuret. The sulphur and oxygen are eventually all separated in the form of sulphurous acid. Roasted galena contains sometimes no less than 77 per cent. of sulphate of lead.

At Vicozago in the Valais, the process of smelting lead ore in the reverberatory furnace with the addition of iron, as practised at Vienne on the Isère, was introduced; but the difficulty of procuring a sufficient supply of old iron has led to an interesting modification.

On the hearth of the reverberatory furnace, 10 quintals of moderately rich ore are spread; these are heated temperately for some time, and stirred about to promote the sublimation of the sulphur. After three or four hours, when the ore seems to be sufficiently de-sulphuretted, the heat is raised so as to melt the whole materials, and whenever they flux into a metallic glass, a few shovelfuls of bruised charcoal or cinders are thrown in, which soon thicken the liquid, and cause metallic lead to appear. By this means three-fourths of the lead contained in the ore are usually extracted: but at length the substance becoming less and less fluid, yields no more metal. Stamped and washed carbonate of iron (sparry iron ore) is now added, in the proportion of about 10 per cent. of the lead ore primarily introduced.

On stirring and working together this mixture, it assumes the consistence of a stiff paste, which is raked out of the furnace. When this has become cold, it is broken into pieces, and thereafter smelted in a slag-hearth, without the addition of flux. By this operation, almost the whole lead present is obtained. 100 quintals of schlich yield 45 of argentiferous lead; and in the production of 100 quintals (cwt.) of marketable lead, 140 cubic feet of beech-wood, and 357½ quintals of charcoal are consumed.

This process is remarkable for the use of iron-ore in smelting galena.

10. *Reduction in the reverberatory furnace, of the litharge obtained in the refining of lead.* — The litharge of Alston Moor is seldom sold as such, but is usually converted into lead, in a reverberatory furnace.

In commencing this reduction, a bed of coal about 2 inches thick is first of all laid on the hearth; which is soon kindled by the flame of the fire-place, and in a little while is reduced to red-hot cinders. Upon these a certain quantity of a mixture of litharge and small coal is uniformly spread; the heat of the fire-place being meanwhile so managed as to maintain in the furnace a suitable temperature for enabling the combustible to deprive the litharge of its oxygen, and to convert it into lead. The metal is run out by the tap-hole into an iron pot; and being cast into pigs of half a hundred-weight, is sold under the name of refined lead at a superior price.

The quantity of small coal mixed with the litharge, should be somewhat less than what may be necessary to effect the reduction, because if in the course of the process, a deficiency of it is perceived in any part of the furnace, more can always be added; whereas a redundancy of coal necessarily increases the quantity of slag, which, at the end of the shift, must be removed from the furnace before a new operation is begun, whereby lead is lost. In the reverberatory furnace, six fodders of lead may be revived in nine or ten hours; during the first six of which the mixture of litharge and coal is added at short intervals. A fodder is from 21 to 24 cwt.

It deserves to be remarked that the work does not go on so well nor so quick when the coal and litharge are in a pulverulent form; because the reduction in this case takes place only at the surface, the air not being able to penetrate into the body, and to keep up its combustion, and the mutual action of the litharge and carbon in the interior. But on the other hand, when the litharge is in porous pieces as large as a hen's egg, the action pervades the whole body, and the sooty fumes of the coal effect the reduction

even in the centre of the fragments of the litharge, penetrating into every fissure and carrying off the oxygen. The heat ought never to be urged so far as to melt the litharge.

The grounds of the cupel, and the slag of the reduction furnace, being a mixture of small coke, coal ash, and oxide of iron, more or less impregnated with lead, are smelted upon the *slag hearth*, along with coke, and by way of flux, with a certain quantity of the black scorias obtained from the same furnace, prepared for this purpose, by running it out in thin plates, and breaking it into small pieces. The lead thus obtained is usually very white, very hard, and not susceptible of refinement.

MM. Dufrénoy and Beaumont consider the smelting of lead ore by the reverberatory furnace as practised in Derbyshire, as probably preferable to that with the slag hearth as carried on in Brittany; a process which seldom gives uniform products, while it occasions a more considerable waste of lead, and consumption of fuel.

The mixed process employed in Cumberland of roasting the ore, and afterwards smelting it in a small furnace resembling that called the Scotch, apparently yields a little less lead than if both operations were executed in the reverberatory furnace; but according to Mr. Forster (see his *Treatise on a Section of the Strata from Newcastle upon Tyne, &c.*), this slight loss is more than compensated by the smaller consumption of fuel, the increased rapidity of the operation, and especially by the much greater purity of the lead obtained from the Scotch furnace. When it comes to be refined, the loss is only about one-twelfth or one-thirteenth, whereas the lead revived in the reverberatory furnace loses frequently a ninth. Moreover, the lead furnished by the first method admits of being refined with profit, when it yields only 5 ounces of silver per fodder of 20 quintals, *poids de marc*, while that produced by the reverberatory furnace cannot be cupelled unless it gives 10 ounces per fodder; and as in the English cupellation, lead is constantly added anew without skimming, the litharge obtained in the second case can never be brought into the market, whereas the litharge of the leads from the Scotch furnace is of good quality. See the new method of enriching lead for cupellation, under *SILVER*.

As the *smelting* of galena, the principal ore of lead, is not a little complex, the following tabular view of the different processes may prove acceptable to the metallurgist:—

| | | Treatment of | Process of | |
|--|---|---|---|----------------------------------|
| I. Class. Treated in reverberatory furnaces. | A. De-sulphuration by roasting. | 1. Pure ores. | Pesey, Spain, &c. England, in general. | |
| | | 2. Ores mixed with saline gangues. | | |
| | | 3. Ores mixed with earthy gangues. | Vicenago in Italy, and Redruth in Cornwall. | |
| | B. De-sulphuration by iron. | 4. Ores mixed with several sulphurets. | Combined with the above. | |
| | | 5. Ores with earthy, saline, and sulphurous gangues. | | |
| | | 6. Ores with mattes, as at Vienne, in Dauphiny. | | Vienne, Poulouen, and Tarnowitz. |
| II. Class. Treated in the mill-slag-hearth, the <i>fourneau à manche</i> , or Scotch furnace. | A. Founding after roasting in a heap, or in a reverberatory. | 7. Ores producing slags of various silicates. | Mattes, with raw lead. | Many places. |
| | | | Workable lead, without matte. | Villefort. |
| | B. Founding with direct de-sulphuration, by metallic iron. | 8. Ores producing compound silicate slags. | Mattes and workable lead. | Several places. |
| | | | Workable lead. | Pont Gibaud and Scotch furnace. |
| | | 9. Ores producing slags composed of silicates and subsilicates. | Mattes and workable lead. | Baad-Ems, Hartz, Tarnowitz. |
| | | | Poor mattes and workable lead. | Tarnowitz. |

The annual production of lead in Europe may be estimated at about 80,000 tons; of which four-sevenths are produced in England, two-sevenths in Spain, the remainder in Germany and Russia. France does not produce more than one-five-hundredth part of the whole; and only one-fiftieth of its consumption.

See LITHARGE, MINIMUM, or *Red Lead*, SOLDER, SUGAR OF ACETATE OF LEAD, TYPE METAL, and WHITE LEAD.

LEAD-SHOT; (*Plomb de chasse*, Fr.; *Schrot*, *Flintenschrot*, Germ.) The origin of most of the imperfections in the manufacture of lead-shot is the too rapid cooling of the spherules by their being dropped too hot into the water, whereby their surfaces form a solid crust, while their interior remains fluid, and in its subsequent concretion, shrinks, so as to produce the irregularities of the shot.

The patent shot towers originally constructed in England obviate this evil by exposing the fused spherules after they pass through the cullender, to a large body of air during their descent into the water tub placed on the ground. The greatest erection of this kind is probably at Villach in Carinthia, being 240 Vienna, or 249 English feet high.

The quantity of arsenic added to the mass of melted lead varies according to the quality of this metal; the harder and less ductile the lead is, the more arsenic must be added. About 3 pounds of either white arsenic or orpiment is enough for one thousand parts of soft lead, and about 8 for the coarser kinds. The latter are employed preferably for shot, as they are cheaper and answer sufficiently well. The arsenical alloy is made either by introducing some of this substance at each melting; or by making a quantity of the compound considerably stronger at once, and adding a certain portion of this to each charge of lead. If the particles of the shot appear lens-shaped, it is a proof that the proportion of arsenic has been too great; but if they are flattened upon one side, if they are hollowed in their middle, called *cupping* by the workman, or drag with a tail behind them, the proportion of arsenic is too small.

The following is the process prescribed by the patentees, Ackerman and Martin. Melt a ton of soft lead, and sprinkle round its sides in the iron pot, about two shovelfuls of wood ashes, taking care to leave the centre clear; then put into the middle about 40 pounds of arsenic to form a rich alloy with the lead. Cover the pot with an iron lid, and lute the joints quickly with loam or mortar to confine the arsenical vapours, keeping up a moderate fire to maintain the mixture fluid for three or four hours; after which skim carefully, and run the alloy into moulds to form ingots or pigs. The composition thus made is to be put in the proportion of one pig or ingot into 1000 pounds of melted ordinary lead. When the whole is well combined, take a perforated skimmer, and let a few drops of it fall from some height into a tub of water. If they do not appear globular, some more arsenical alloy must be added.

Lead which contains a good deal of pewter or tin must be rejected, because it tends to produce elongated drops or tails.

From two to three tons are usually melted at once in the large establishments. The surface of the lead gets covered with a crust of oxide of a white spongy nature, sometimes called *cream* by the workmen, which is of use to coat over the bottom of the cullender, because without such a bed the heavy melted lead would run too rapidly through the holes for the granulating process, and would form oblong spheroids. The mounting of this filter, or lining of the cullender, is reckoned to be a nice operation by the workmen, and is regarded usually as a valuable secret.

The cullenders are hollow hemispheres of sheet iron about 10 inches in diameter, perforated with holes, which should be perfectly round and free from burrs. These must be of an uniform size in each cullender; but of course a series of different cullenders with sorted holes for every different size of lead-shot must be prepared. The holes have nearly the following diameters for the annexed numbers of shot.

| No. | 0. | - | - | - | - | $\frac{1}{10}$ of an inch. |
|-----|----|---|---|---|---|----------------------------|
| 1. | - | - | - | - | - | $\frac{1}{10}$ — |
| 2. | - | - | - | - | - | $\frac{1}{8}$ — |
| 3. | - | - | - | - | - | $\frac{3}{16}$ — |
| 4. | - | - | - | - | - | $\frac{1}{4}$ — |

From No. 5. to No. 9. the diameter decreases by regular gradations, the latter being only $\frac{1}{30}$ of an inch.

The operation is always carried on with three cullenders at a time; which are supported upon projecting grates of a kind of chafing dish made of sheet iron somewhat like a triangle. This chafing dish should be placed immediately above the fall; while at its bottom there must be a tub half filled with water for receiving the granulated lead. The cullenders are not in contact, but must be parted by burning charcoal in order to keep the lead constantly at the proper temperature, and to prevent its solidifying in the filter. The temperature of the lead bath should vary with the size of the shot; for the

largest, it should be such that a bit of straw plunged into it will be scarcely browned, but for all it should be nicely regulated. The height from which the particles should be let fall varies likewise with the size of the shot; as the congelation is the more rapid, the smaller they are. With a fall of 99 yards or 100 feet, from No. 4. to No. 9. may be made; but for larger sizes, 150 feet of height will be required.

Every thing being arranged as above described, the workman puts the filter-stuff into the cullender, pressing it well against the sides. He next pours lead into it with an iron ladle, but not in too great quantity at a time, lest it should run through too fast. The shot thereby formed and found in the tub are not all equal.

The centre of the cullender being less hot affords larger shot than the sides, which are constantly surrounded with burning charcoal. Occasionally, also, the three cullenders employed together may have holes of different sizes, in which case the tub may contain shot of very various magnitudes. These are separated from each other by square sieves of different fineness, 10 inches broad and 16 inches long, their bottoms being of sheet iron pierced with holes of the same diameters as those of the cullenders. These sieves are suspended by means of two bands above boxes for receiving the shot; one sieve being usually set above another in consecutive numbers, for instance 1. and 2. The shot being put into the upper sieve, No. 0. will remain in it; No. 1. will remain in the lower sieve, and No. 2. will, with all the others, pass through it into the chest below. It is obvious that by substituting sieves of successive fineness, shot of any dimension may be sorted.

In the preceding process the shot has been sorted to size; it must next be sorted to form, so as to separate all the spheroids which are not truly round, or are defective in any respect. For this purpose a board is made use of about 27 inches long and 16 broad, furnished partially with upright ledges; upon this tray a handful or two of the shot to be sorted being laid, it is inclined very slightly, and gently shaken in the horizontal direction, when the globular particles run down by one edge, into a chest set to receive them, while those of irregular forms remain on the sides of the tray, and are reserved to be re-melted.

After being sorted in this way, the shot requires still to be smoothed and polished bright. This object is effected by putting it into a small octagonal cask, through a door in its side, turning upon a horizontal iron axis, with rests in plummer boxes at its ends, and is made to revolve by any mechanical power. A certain quantity of plumbago or black lead is put in along with the shot.

LEAD acted on by pure water so as to make it poisonous.—Dr. H. Guenaude Musy was summoned to Claremont in the beginning of October, 1848; and, on his arrival was shown into the room of one of the members of the ex-royal family of France, who had been residing there since the preceding March. He found him lying down, with an anxious countenance, the conjunctiva of a yellowish colour, and the flesh flabby, evidently proving a loss of substance. He told him he had been suffering for several days from violent colics which had been relieved after a constipation of two days by abundant alvine evacuations produced by a purgative draught. This was the third attack of the same nature during the space of five weeks. Some time before, towards the end of July, he had been suffering from colic, with nausea, frequent eructations and irregularity of the bowels.

“I learnt that a brother of my patient had experienced the same symptoms: but no one was astonished at it, as it was supposed he was suffering under a liver complaint contracted on the western coast of Africa.

“A third patient, of forty-eight years of age, who was also subject to constipation, had violent colic a few days before, attended with nausea and even vomiting.

“A few days elapsed and no bad symptoms disturbed our security. My patients had resumed their usual occupations, and good appetites and pretty fair digestion, but were still very weak; and pale sallow complexions had replaced the icteric colour.

“My delusions did not last long. About ten days after, a new access of symptoms began, with a painful sensation of constriction about the epigastric region, anxiety, nausea, and eructations.”

After describing the symptoms and the treatment resorted to before the real cause of the disorder was suspected, the doctor mentions the circumstances which led to the discovery, which induced him to administer sulphur in combination with iron internally, and to order sulphurous and soapy baths. He proceeds:—

“The chemical action showed itself almost immediately by the black discolouration of the nails of the feet and hands, and by the appearance of similar spots on different parts of the skin.

“One of the patients came out from the second bath with the abdomen entirely black. The soapy frictions and baths usually washed away the spots from the skin, but not those of the nails. The appearance of this reaction, which is very common with men

working in lead manufactories when using sulphurous baths, is explained by the combination of sulphur with the saturnine molecules adhering to the skin.

"In these cases it was evident that the lead was brought to the surface of the body by means either of sudaminal or follicular exhalations, and perhaps by both.

"The metal is eliminated and transformed into sulphuret of lead by the sulphurous baths, and then taken off by the soapy frictions and baths.

"These were not useless, for without them the lead deposited on the surface might have been carried again by absorption into the economy.

"But the skin was not the only means of giving exit to the poison. I discovered it in the urine by a solution of hydrosulphate of ammonia. Some physicians and chemists look on sulphur as the only efficacious remedy; others, on the contrary, assert that it is without any effect.

"What I can tell you is, that the success was beyond my hopes. After two or three weeks I had the satisfaction of seeing my patients progressing rapidly and surely towards recovery. This happy result induced me to try the same means with another person, older and of a weaker constitution, and consequently for whom I was most uneasy, and the result was as satisfactory.

"One of my patients was accustomed to drink Vichy water at table. This was a very unfortunate predisposing circumstance: it is probable that the salt of Vichy water, i. e. bicarbonate of soda, united to the bed of Claremont water, had much to do with the violence of the attack under which he suffered.

"At the time of my arrival at Claremont, there were thirty-eight inhabitants.

"Thirteen of these had been attacked, eleven men and two women. Four of them had some symptoms two months previously to my arrival, the other cases occurred under my own eyes. Some even after the pipes had been cut off were affected, and one when on the continent a week after leaving England.

"Six children in the household, aged from three to seven years, have been exempt from it. Only half of the patients have had the gums marked with the slate coloured line and spots of the same colour on the mucous membrane of the mouth, and these spots and the bluish line of the gums, were observed on several others who did not experience or exhibit anything else, and those signs of the poison having been taken into the economy have not yet disappeared. The morbid cause has acted in these cases, as it often does, with caprice, and according to individual dispositions which defy every reasoning.

"The malady has shown no respect for condition, and attacked indiscriminately servants, aides-de-camps and princes.

"The spring that furnishes the palace of Claremont with water issues from a sand bed at about two miles distance. It was chosen for its uncommon purity from among a great many others in its vicinity, and the water was thirty years ago conducted to the palace through leaden pipes. In the present day some other metal would perhaps have been selected, for experience has taught us that pure water, and especially distilled water, acts rapidly on lead when it comes in contact with it.

"Thus Tronchin proved that the inhabitants of Amsterdam were indebted to the rain water, kept in leaden cisterns, for the colic they were so much subject to in his time.

"The purity of the Claremont water becomes a most dangerous property, and not only to it but to other springs. Whilst I was combating its pernicious effects, I heard that there had been several similar cases in different parts of England; they are not uncommon in the county of Surrey, and especially in the neighbourhood of Claremont. Besides the cases published by Dr. Thompson, I know of several others at Weybridge, Windsor, and in different other places.

"I should inform you that Professor Hoffman has ascertained the quantity of metallic lead contained in the water examined by him. He has found that it amounted to a grain per gallon, an enormous quantity when we consider that the poisoned water was used in all culinary and table purposes; and, previously to the discovery of its deleterious character, even in the preparation of pitisans and lavements."

LEAD SHOT has been manufactured in the United States in low towers, provided with an ascending stream of air, drawn up by a fan worked by water-power, whereby a like cooling effect is obtained as by letting the melted lead fall from a high tower.

LEATHER, (*Cuir*, Fr.; *Leder*, Germ.); is the skin of animals, so modified by chemical means as to have become unalterable by the external agents which tend to decompose it in its natural state. The preparation in a rude manner of this valuable substance has been known from the most ancient times, but it was not till the end of the last, and the beginning of the present century, that it began to be manufactured upon right principles, in consequence of the researches of Macbride, Deyeux, Seguin, and Davy. There are several varieties of leather; such as sole leather, boot or upper leather, shamoy leather, kid or glove leather, &c. Skins may be converted into leather either with or without their hairy coat.

We shall treat first of sole and upper leathers, being the most important, and most

costly and difficult to prepare in a proper manner. These kinds consist of organized fibrous gelatine or skin, combined with the proximate vegetable principle, tannin, and probably also some vegetable extractive. Under the articles GALLS and TANNIN, will be found an account of the properties of this substance, and the means of obtaining it in a state of purity. Calf leather quickly tanned by an infusion of galls, consists of 61 parts of skin, and 39 of vegetable matter in 100 by weight; by solution of catechu, it consists of 80 of skin, and 20 of vegetable matter; by infusion of Leicester willow, of 74.5 skin, and 25.5 vegetable matter; and by infusion of oak bark, of 73.2 skin, and 26.8 vegetable matter. By the slow process of tanning, continued for three months, the increase of weight upon the skin in its conversion into leather, is greatly less; the vegetable constituents being from Leicester willow only 13 per cent. of the leather, and from oak bark 15 per cent. Sole leather, however, generally contains no less than 40 per cent. of vegetable matter. In every astringent bark, the inner white part next to the *alburnum*, contains the largest quantity of tannin, and the middle coloured part contains most extractive matter. The outer surface or epidermis seldom furnishes either tannin or extractive matter. Young trees abound most in the white cortical layers, and are hence more productive of tannin under equal weights, than the barks of old trees. In no case is there any reason to believe that the gallic acid of astringent vegetables is absorbed in the process of making leather; hence Seguin's theory of the agency of that substance in disoxygenating skin, falls to the ground. The different qualities of leather made with the same kind of skin, seem to depend very much upon the different quantities of extractive matter it may have absorbed. The leather made with infusion of galls, is generally harder and more liable to crack than the leather obtained from infusions of barks; and it always contains a much larger proportion of tannin, and a smaller proportion of extractive matter.

When calf skin is slowly tanned in weak solutions of the bark, or of catechu, it combines with a good deal of extractive matter, and though the increase of the weight of the skin be comparatively small, yet it has become perfectly insoluble in water, forming a soft, but at the same time a strong leather. The saturated infusions of astringent barks contain much less extractive matter in proportion to their tannin, than the weak infusions; and when skin is quickly tanned in the former, it produces a worse and less durable leather than when slowly tanned in the latter. In quick tanning, a considerable quantity of vegetable extractive matter is thus lost to the manufacturer, which might have been made to enter as a useful constituent into the leather. These observations show that there is sufficient foundation for the opinion of the common workmen, concerning what is technically called *feeding* of leather, in the slow method of tanning; and though the processes of this art have been unnecessarily protracted by defective methods of steeping, and want of progressive infiltration of the astringent liquor through the skins, yet in general they appear to have arrived, in consequence of old experience, at a degree of perfection in the quality of the leather, which cannot be far exceeded by means of any theoretical suggestions which have been advanced.

On the first view it may appear surprising, that in those cases of quick tanning, where extractive matter forms a certain portion of the leather, the increase of weight is less than when the skin is combined with the pure tannin; but the fact is easily accounted for, when we consider that the attraction of skin for tannin must be probably weakened by its union with extractive matter; and whether we suppose that the tannin and extractive matter enter together into combination with the matter of skin, or unite with separate portions of it, still, in either case, the primary attraction of skin for tan must be to a certain extent diminished.

In examining astringent vegetables in relation to their power of making leather, it is necessary to take into account not only the quantity they may contain of the *substance* precipitable by gelatine, but likewise the quantity and the nature of the extractive matter; and in cases of comparison, it is essential to employ infusions of the same degree of concentration.

Of all astringent substances hitherto examined, catechu is that which contains the largest proportion of tannin; and in supposing, according to the usual estimation, that from four to five pounds of common oak bark are required to produce one pound of leather, it appears, from the various synthetical experiments, that about half a pound of catechu would answer the same purpose. Mr. Purkis found, by the results of different accurate experiments, that 1 pound of catechu was equivalent to 7 or 8 of oak bark. For the common purposes of the tanner, 1 pound of it would be equivalent also to 2½ pounds of galls, to 7½ of the Leicester willow, to 11 of the bark of the Spanish chesnut, to 18 of the bark of the common elm, to 21 of the bark of the common willow, and to 3 pounds of sumach.

Various menstrua have been proposed for the purpose of expediting and improving the process of tanning, among others, lime water, and solution of pearl-ash; but as these two substances form compounds with tannin which are not decomposable by gelatine, it

follows that their effects must be prejudicial. There is very little reason to suppose that any bodies will be found which, at the same time that they increase the solubility of tannin in water, will not likewise diminish its attraction for skin.

In this country all tanned leather is distinguished into two kinds, called *hides* and *skins*; the former term being appropriated to that made from the larger animals, as bulls, buffaloes, oxen, and cows, into thick strong sole leather; and the latter to that made from calves, seals, &c., into thinner and more flexible upper leather. Sometimes the hides are brought into the market merely dried, as from Buenos-Ayres; or dried and salted, as from Bahia and Pernambuco; but the greater part are fresh from recently slaughtered animals. The heaviest ox hides are preferred for forming *butts* or *backs*, which are manufactured as follows:—

The washing process must be more or less elaborate, according to the state of the skins. Those that are salted and dry require to be steeped, beaten, and rubbed several times alternately, to bring them to the fresh condition.

After removing the horns, the softened or recent hides are laid in a heap for two or three days, after which they are suspended on poles in a close room called a smoke-house, heated somewhat above the common temperature by a smouldering fire. In these circumstances, a slight putrefaction supervenes, which loosens the epidermis, and renders the hair easily detachable by the *fleshing* knife; a large two-handled implement, with a blunt edge, and bent to suit the curvature of the rounded beam of the wooden horse upon which the hide is scraped. See *CURRYING*.

The next step is immersion in a pit containing water impregnated with about a 1000th part of sulphuric acid. This process is called *raising*, because it distends the pores, and makes the fibres swell, so as to render the skins more susceptible of the action of the tanning infusions. Forty-eight hours in general suffice for this operation, but more time may be safely taken.

When the hides are found to be sufficiently raised, they are transferred to a pit, in which they are stratified with oak bark, ground by a proper mill into a coarse powder. The pit is then filled up with an infusion of oak bark called *ooze*, and the hides are allowed to remain in it for about a month or six weeks. By this time the tannin and extractive matter of the bark having combined intimately with the animal fibre, the pit is exhausted of its virtue, and must be renewed, by taking out the spent bark, and subjecting the skins to a fresh dose of oak bark and *ooze*. The hides which were placed near the top of the first pit, must be placed near the bottom of the next. In this mixture they remain, upon the old practice, about three months. The last process being repeated twice or thrice, perfectly tanned leather is the result. The hides are now removed from the pit, and hung up in a shed. In the progress of drying, which should be slow, they are compressed with a steel tool, and beaten smooth, to render them more firm and dense.

Some manufacturers place on the bottom of the pit 5 or 6 inches of spent bark, over it 2 inches of fresh bark, then a skin; and so, alternately, a layer of new bark and a skin, till the pit is nearly full, reserving a small space at top for a thicker layer of bark, over which weighted boards are laid, to condense the whole down into the tanning infusion.

The operation of tanning sole leather in the above way, lasts a year or a year and a half, according to the quality wanted, and the nature of the hides.

A perfect leather is recognized by its section, which should have a glistening marbled appearance, without any white streaks in the middle.

Crop hides are manufactured by immersion, during three or four days, in pits containing milk of lime; in which they are occasionally moved up and down in order to expose them equally to the action of this menstruum. They are then removed, and cleared from hair and impurities, by using the fleshing knife upon the horse; after which they must be completely freed from the lime by a thorough washing. They are next plunged in pits containing a weak *ooze* or infusion of oak bark, from which they are successively transferred into other pits with stronger *ooze*; all the while being daily *handed*, that is, moved up and down in the infusion. This practice is continued for about a month or six weeks. They are now ready to be subjected to a mixture of ground oak bark and stronger *ooze* in other pits, to a series of which they are progressively subjected during two or three months.

The hides are next put into large vats, called *layers*, in which they are smoothly stratified with more oak bark, and a stronger infusion of it. After six weeks they are taken out of these vats, and subjected to a new charge of the same materials for two months. This simple process is repeated twice or thrice, at the option of the manufacturer, till the hides are thoroughly tanned. They are then slowly dried, and condensed in the manner above described. These *crop hides* form the principal part of the sole leather used for home consumption in England.

The process of tanning *skins* (as of calves, seals, &c.) is in some respects peculiar. They are left in the lime pits for about twelve days, when they are stripped of their

hair, washed in water, then immersed in a lixivium of pigeons' dung, called a *grainer*, of an alkaline nature. Here they remain from eight to ten days, according to the state of the atmosphere, during which time they are frequently handled, and scraped on both sides upon a convex wooden beam. This scraping or *working*, as it is termed, joined to the action of the *grainer*, serves to separate the lime, oil, and glutinous matter, and to render the skin pliant, soft, and ready to imbibe the tanning principle. They are with this view transferred into pits containing a weak solution of bark, in which they undergo nearly the same treatment as described above for *crop* hides; but they are not commonly stratified in the layers. The time occupied in tanning them is usually limited to three months. They are then dried, and disposed of to the currier, who dresses and blackens them for the upper leathers of boots and shoes, for harness, and other purposes. The light and thin sorts of cow and horse hides are often treated like calf skins.

In all the above processes, as the animal fibres on the surface of the skin absorb most readily the tanning principles, and thereby obstruct, in a certain degree, their passage into the interior fibres, especially of thick hides, it becomes an object of importance to contrive some method of overcoming that obstacle, and promoting the penetration of the tan. The first manufacturer who appears to have employed efficacious mechanical means of favouring the chemical action was Francis G. Spilsbury, who in April, 1823, obtained a patent for the following operation: — After the hides are freed from the hairs, &c. in the usual way, they are minutely inspected as to their soundness, and if any holes be found, they are carefully sewed up, so as to be water tight. Three frames of wood are provided of equal dimensions, fitted to each other, with the edges of the frames held together by screw bolts. A skin about to be tanned is now laid upon the frame, and stretched over its edges, then the second frame is to be placed upon it, so that the edges of the two frames may pinch the skin all round and hold it securely; another such skin is then stretched over the upper surface of the second frame, in like manner, and a third frame being set upon this, confines the second skin. The three frames are then pinched tightly together by a series of screw bolts, passing through ears set round their outer edges, which fix the skin in a proper manner for being operated upon by the tanning liquor.

A space has been thus formed between the two skins, into which, when the frames are set upright, the infusion is introduced by means of a pipe from the cistern above, while the air is permitted to escape by a stopcock below. This cock must of course be shut whenever the bag is filled, but the one above is left open to maintain a communication with the liquor cistern, and to allow the hydrostatic pressure to force the liquor through the cutaneous pores by a slow infiltration, and thus to bring the tannin into contact with all the fibres indiscriminately. The action of this pressure is evinced by a constant perspiration on the outer surfaces of the skins.

When the tanning is completed, the upper stopcock is closed, and the under is opened to run off the liquor. The frames are now removed, the bolts are unscrewed, and the pinched edges of the skins pared off; after which they are to be dried and finished in the usual manner.

A modification of this ingenious and effectual process was made the subject of a patent, by William Drake, of Bedminster, tanner, in October, 1831. The hides, after the usual preparatory processes, are immersed in a weak tan liquor, and by frequent handling or turning over, receive an incipient tanning before being submitted to the infiltration plan. Two hides, as nearly of the same size and shape as possible, are placed grain to grain, when their corresponding edges are sewed firmly together all round by shoemaker's waxed thread, so as to form a bag sufficiently tight to hold tan liquor. This bag must then be suspended by means of loops sewed to its shoulder end, upon pegs, in such a manner that it may hang within a wooden-barred rack, and be confined laterally into a book form. About an inch of the bag is left unsewed at the upper end, for the purpose of introducing a funnel through which the cold tan liquor is poured into the bag till it be full. After a certain interval which varies with the quality of the hides, the outer surface becomes moist, and drops begin to form at the bottom of the bag. These are received in a proper vessel, and when they accumulate sufficiently may be poured back into the funnel; the bag being thus, as well as by a fresh supply from above, kept constantly distended.

When the hides are observed to feel hard and firm, while every part of them feels equally damp, the air of the tanning apartment having been always well ventilated, is now to be heated by proper means to a temperature gradually increasing from 70° to 150° of Fahrenheit's scale. This heat is to be maintained till the hides become firmer and harder in all parts. When they begin to assume a black appearance in some parts, and when the tan liquor undergoes little diminution, the hides may be considered to be tanned, and the bag may be emptied by cutting a few stitches at its bottom. The outer edges being pared off, the hides are to be finished in the usual way. During

their suspension within the racks, the hides should be shifted a little sideways, to prevent the formation of furrows by the bars, and to facilitate the equable action of the liquor.

By this process the patentee says, that a hide may be tanned as completely in ten days as it could be in ten months by the usual method. I have seen a piece of sole leather thus rapidly tanned, and it seemed to be perfect. How it may wear, compared with that made in the old way, I cannot pretend to determine.

Messrs. Knowlys and Ducsbury obtained a patent in August, 1826, for accelerating the impregnation of skins with tannin, by suspending them in a close vessel, from which the air is to be extracted by an air pump, and then the tanning infusion is to be admitted. In this way, it is supposed to penetrate the hide so effectually as to tan it uniformly in a short time.

About 40 years ago, a similar vacuum scheme was employed to impregnate with weaver's paste or starch, the cops of cotton weft, for the dandy looms of Messrs. Radcliff and Ross, of Stockport.

Danish leather is made by tanning lamb and kid skins with willow bark, whence it derives an agreeable smell. It is chiefly worked up into gloves.

Of the tawing or dressing of skins for gloves, and white sheep leather.

The operations of this art are: 1. washing the skins; 2. properly treating them with lime; 3. taking off the fleece; 4. treatment in the leather steep.

A shed erected upon the side of a stream, with a cistern of water for washing the skins; wooden horses for cleaning them with the back of the fleshing knife; pincers for removing the fibres of damaged wool; a plunger for depressing the skins in the pits; a lime pit; a pole with a bag tied to the end of it; a two-handed fleshing knife; a rolling pin, from 15 to 18 inches long, thickened in the middle; such are some of the utensils of a tawing establishment. There must be provided also a table for applying the oil to the skins; a fulling mill, worked by a water-wheel or other power; a dressing peg; a press for squeezing out the fatty filth; a stove; planks mounted upon legs, for stretching the skins, &c.

Fresh skins must be worked immediately after being washed, and then dried, otherwise they ferment, and contract either indelible spots, or get tender in certain points, so as to open up and tear under the tools. When received in the dry state they should be steeped in water for two days, and then treated as fresh skins. They are next strongly rubbed on the convex horse-beam with a round-edged knife, in order to make them pliant. The rough parts are removed by the fleshing knife. One workman can in this way prepare 200 skins in a day.

The flesh side of each being rubbed with a cold cream of lime, the skins are piled together with the woolly side of each pair outermost, and the flesh sides in contact. They are left in this state for a few days, till it is found that the wool may be easily removed by *plucking*.

They are next washed in running water, to separate the greater part of the lime, stripped of the wool by small spring tweezers, and then fleeced smooth by means of the rolling-pin, or sometimes by rubbing with a whetstone. Unless they be fleeced soon after the treatment with lime, they do not well admit of this operation subsequently, as they are apt to get hard.

They are now steeped in the milk of lime-pit, in order to swell, soften, and cleanse them; afterwards in a weak pit of old lime-water, from which they are taken out and drained. This steeping and draining upon inclined tables, are repeated frequently during the space of 3 weeks. Only the skins of young animals, or those of inferior value are tawed. Sometimes the wool is left on, as for housings, &c.

The skins, after having been well softened in the steeps, are rubbed on the outside with a whetstone set in a wooden case with two handles, in order to smooth them completely by removing any remaining filaments of wool. Lamb skins are rubbed with the pin in the direction of their breadth, to give them suppleness; but sheep skins are felled with water alone. They are now ready for the *branning*, which is done by mixing 40 lbs. of bran with 20 gallons of water, and keeping them in this fermentable mixture for three weeks — with the addition, if possible, of some old bran water. Here they must be frequently turned over, and carefully watched, as it is a delicate operation. In the course of two days in summer, and eight in winter, the skins are said to be *raised*, when they sink in the water. On coming out of the bran, they are ready for the white stuff; which is a bath composed of alum and sea-salt. Twelve, fourteen, and sometimes eighteen pounds of alum for 100 skins, form the basis of the bath; to which two and a half pounds of salt are added in winter, and three in summer. These ingredients are introduced into a copper with twelve gallons of water. The salt aids in the whitening action. When the solution is about to boil, three gallons of it are

passed through the cullender into a basin; in this 26 skins are worked one after another, and after draining, they are put together into the bath, and left in it for ten minutes to imbibe the salts. They are now ready to receive the paste. For 100 skins, from 13 to 15 pounds of wheat flour are used along with the yolks of 50 eggs. After having warmed the alum bath through which the skins have been passed, the flour is dusted into it, with careful stirring. The paste is well kneaded by the gradual addition of the solution, and passed through the cullender, whereby it becomes as clear as honey. To this the yolks being added, the whole is incorporated with much manual labour. The skins are worked one after another in this paste; and afterwards the whole together are left immersed in it for a day. They are now stretched and dried upon poles, in a proper apartment, during from 8 to 15 days, according to the season.

The effects of the paste are to whiten the skins, to soften them, and to protect them from the hardening influence of the atmosphere, which would naturally render them brittle. They would not bear working upon the *softening iron*, but for the emulsion which has been introduced into their substance. With this view they are dipped in a tub of clear water during five or six minutes, and then spread and worked upon the board. They are increased by this means in length, in the proportion of 5 to 3. No hard points must be left in them. The whiteness is also better brought out by this operation, which is performed upon the flesh side. The softening tool is an iron plate, about one foot broad, rounded over above, mounted upon an upright beam, 30 inches high, which is fixed to the end of a strong horizontal plank, 3½ feet long, and 1 broad. This plank is heavily loaded, to make it immovable upon the floor. Sometimes the skins are next spread over an undressed clean skin upon the horse, and worked well with the two-handed knife, for the purpose of removing the first and second epidermis, called the *fleur* and *arrière-fleur* by the French *megisiers*. They are then dried while stretched by hooks and strings. When dry they are worked on the *stretching iron*, or they are occasionally polished with pumice stone. A delicate yellow tint is given by a composition made of two parts of whitening, and one of ochre, applied in a moistened state, and well worked in upon the grain side. After being polished with pumice, they are smoothed with a hot iron, as the laundresses do linen, whereby they acquire a degree of lustre, and are ready to be delivered to the *glover*.

For *housings*, the best sheepskins are selected, and such as are covered with the longest and most beautiful fleece. They are steeped in water, in order to be cleaned and softened; after which they are thinned inside by the fleshing knife. They are now steeped in an old bran pit for 3 or 4 days, when they are taken out and washed. They are next subjected to the white or alum bath, the wool being carefully folded within; about 18 pounds of alum being used for 100 skins. The paste is made as for the fleeced skins, but it is merely spread upon their flesh side, and left upon them for 18 hours, so as to stiffen. They are then hung up to dry. They are next moistened by sprinkling cold water upon them, folded up, piled in a heap, and covered with boards weighted with heavy stones; in which state they remain for two days. They are next opened with a round iron upon the horse, and subjected to the stretching iron, being worked broadwise. They are dried with the fleece outermost, in the sun if possible; and are finished upon the *stretcher*.

Calf and lamb skins with their hair and wool are worked nearly in the same manner; only the thicker the skin, the stronger the alum bath ought to be. One pound of alum and one of salt are required for a single calf skin. It is left four days in this bath, after which it is worked upon the *stretcher*, then felled. When half dry the skins are opened upon the horse. In eight days of ordinary weather, they may be completely dressed. Lamb skins are sometimes steeped during eight days in a bath prepared with unbolted rye flour and cold water, in which they are daily moved about two or three times. They are then dried, stretched upon the iron, and switched upon the fleecy side.

Chamois or Shamo leather. — The skins are first washed, limed, fleeced, and branned as above described. They are next *efflowered*, that is, deprived of their epidermis by a concave knife, blunt in its middle part, upon the convex horse-beam. The cutting part serves to remove all excrescences, and to equalize the thickness, while the blunt part softens and smooths. The skins of goats, does, and chamois are always treated in this way. They are next subjected to the fermenting bran steep for one or two days, in ordinary weather; but in hot weather for a much shorter time, sometimes only moving them in the sour bran liquor for a few minutes. They are lastly wrung at the peg, and subjected to the fulling mill.

When the skins have been sufficiently swelled and supplied by the branning, they may receive the first oil as follows: a dozen skins being stretched upon the table, the fingers are dipped in the oil, and shaken over the skins in different places, so as to impart enough of it to imbue the whole surface slightly, by friction with the palms of the hands. It is to the outside or *grain* that the oil is applied. The skins are folded four together, so as to form balls of the size of a hog's bladder, and thrown into the trough

of the fulling mill, to the number of twelve dozen at once. Here they remain exposed to the beater for two, three, or four hours, according to their nature and the state of the weather. They are taken out, aired, oiled, and again fullled. The airing and fulling are repeated several times, with more or less frequent oilings. Any cheap animal oil is employed.

After these operations, the skins require to be subjected to a fermenting process, to dilate their pores, and to facilitate their combination with the oil. This is performed in a chamber only 6 feet high, and 10 or 12 feet square. Poles are suspended horizontally a few inches from the ceiling, with hooks fixed in them to which the skins are attached. A somewhat elevated temperature is maintained, and by a stove if need be. This operation requires great skill and experience.

The remainder of the epidermis is next removed by a blunt concave knife and the horse; whereby the surface is not cut, but rather forcibly scraped.

The skins are now scoured to carry off the redundant oil; which is effected by a potash lye, at 2° Baumé, heated no hotter than the hand can bear. In this they are stirred briskly, steeped for an hour, and lastly wrung at the peg. The soapy liquor thus expelled is used for inferior purposes. The clean skins after being dried are finished first on the *stretcher-iron*, and then on the *herse* or stretching frame.

Leather of Hungary.—This is manufactured by impregnating strong hides with alum, common salt, and suet; by a rapid process which is usually completed in the space of two months. The workshop is divided into two parts; 1. a shed on the side of a stream, furnished with wooden horses, fleshing knives, and other small tools. In one corner is a furnace with a boiler for dissolving the alum, a vat for immersing the hides in the solution, and several subsidiary tubs. 2. A chamber, 6 feet high, by 15 feet square, capable of being made very tight, for preserving the heat. In one corner is a copper boiler, of sufficient size to contain 170 pounds of tallow. In the middle of the stove is a square stone slab, upon which an iron grate is placed about a yard square. This is covered with charcoal. At each side of the stove are large tables, which occupy its whole length, and on which the leather is spread to receive the grease. The upper part below the ceiling is filled with poles for hanging the leather upon to be heated. The door is made to shut perfectly close.

The first operations are analogous to those of tanning and tawing; the skins being washed, cut in halves, shaved, and steeped for 24 hours in the river. They are then cleaned with 5 or 6 pounds of alum, and 3½ pounds of salt, for a piece of hide which weighs from 70 to 80 pounds. The common salt softens the effect of the alum, attracts the moisture of the air, and preserves the suppleness of the skin. When the alum and salt are dissolved, hot water is poured upon the hides placed in a vat, and they are tramped upon by a workman walking repeatedly from one end of the vat to the other. They are then transferred into a similar vat containing some hot water, and similarly tramped upon. They are next steeped for eight days in alum water. The same round of operations is repeated a second time.

The skins are now dried either in the air, or a stove room; but before being quite dry, they are doubled together, well stretched to take out the wrinkles, and piled up. When dry, they are again tramped to open the pores as well as to render the skin pliant, after which they are withened by exposure to the sun.

Tallow of inferior quality is employed for greasing the leather. With this view the hides are hung upon the poles in the close stove room, then laid upon the table, and besmeared with the tallow melted till it begins to crackle. This piece is laid on another table, is there covered with a second, similarly greased, and so forth. Three pounds of fat are commonly employed for one piece of leather.

When the thirty strips, or fifteen hides passed through the grease in one operation are completed, two workmen take the first piece in their hands, and stretch it over the burning charcoal on the grate for a minute, with the flesh side to the fire. The rest are passed over the flame in like manner. After *flaming*, the pieces are successively laid on an inclined table exposed to the fire, where they are covered with a cloth. They are finally hung upon poles in the air to dry; and if the weather be warm, they are suspended only during the night, so as to favour the hardening of the grease. Instead of the alum bath, M. Curaudau has employed with advantage a steep of dilute sulphuric acid.

Russia leather.—The Russians have long been possessed of a method of making a peculiar leather, called by them *jucten*, dyed red with the aromatic saunders wood. This article has been much sought after, on account of not being subject to mould in damp situations, being proof against insects, and even repelling them from the vicinity of its odour. The skins are freed from the hair or fleece, by steeping in an ash-lye too weak to act upon the animal fibres. They are then rinsed, fullled for a longer or shorter time according to their nature, and fermented in a proper steep, after having been washed in hot water. They are taken out at the end of a week, but they may be steeped

a second time if deemed necessary, to open their pores. They are now cleaned by working them at the horse on both the flesh and grain sides.

A paste is next composed, for 200 skins, of 38 pounds of rye flour, which is set to ferment with leaven. This dough is worked up with a sufficient quantity of water to form a bath for the skins, in which they are soaked for 48 hours; they are then transferred into small tubs, where they remain during fifteen days, after which they are washed at the river. These operations serve to prepare the skins for absorbing the astringent juices with uniformity. A decoction of willow bark (*salix cinerea* and *salix caprea*) being made, the skins are immersed in the boiler whenever the temperature of the liquor is sufficiently lowered not to injure the animal fibres, and handled and pressed for half an hour. This manipulation is repeated twice daily during the period of a week. The tanning infusion is then renewed, and applied to the same skins for another week; after which, being exposed to the air to dry, they are ready for being dyed, and then carried with the empyreumatic oil of the bark of the birch tree. To this substance the Russia leather owes its peculiarities. Many modes have been prescribed for preparing it; but the following is the one practised in Russia.

The whitish membranous epidermis of the birch, stripped of all woody parts, is introduced into an iron boiler, which, when stuffed full, is covered tight with a vaulted iron lid, having a pipe rising from its centre. A second boiler into which this pipe passes without reaching its bottom, is set over the first, and is luted to it at the edges, after the two are bolted together. They are then inverted, so that the upper one contains the birch bark. The under half of this apparatus is sunk in the earth, the surface of the upper boiler is coated over with a clay lute, then surrounded with a fire of wood, and exposed to a red heat, till the distillation be completed. This operation, though rude in appearance, and wasteful of wood, answers its purpose perfectly well. The iron cylinder apparatus used in Britain for distilling wood vinegar would, however, be much more convenient and productive. When the above bodies are unluted, there is found in the upper one a very light powder of charcoal, and in the under one, which served as a receiver, there is an oily, brown, empyreumatic fluid, of a very strong smell, which is mixed with the tar, and which floats over a small quantity of crude vinegar. The former matter is the oil employed to impregnate the skins, by working it into the flesh side with the currier's tools. It is difficult to make this oil penetrate with uniformity; and the Russians do not always succeed in this process, for they turn out many skins in a spotted state. This oil is at present obtained in France by distilling the birch bark in copper stills, and condensing the products by means of a pipe plunged in cold water. About 60 per cent. of the weight of the bark is extracted.

The skins imbibe this oil most equally before they are fully dry. Care must be taken not to apply too much of it, for fear of its passing through and staining the grain-side of the leather. Chevreul has investigated the chemical nature of this odoriferous substance, and finding it to be a peculiar compound, has called it *betuline*.

In the Franklin Institute for February, 1843, Mr. Gideon Lee has published some judicious observations on the process of tanning. He believes that much of the original gelatine of the hides is never combined with the tannin, but is wasted; for he thinks that 100 lbs. of perfectly dry hide, when cleaned from extraneous matter, should, on chemical principles, afford at least 180 lbs. of leather. The usual preparation of the hide for tanning he believes to be a wasteful process. In the liming and bating, or the unhairing and the cleansing, the general plan is first to steep the hides in milk of lime for one, two, or three weeks, according to the weather and texture of the skin, until the hair and epidermis be so loosened as to be readily removed by rubbing down, by means of a knife, upon a beam or block. Another mode is to suspend the hides in a close chamber, heated slightly by a smouldering fire, till the epidermis gets loosened by incipient putrefaction. A third process, called sweating, used in Germany, consists in laying the hides in a pack or pile, covered with tan, to promote fermentative heat, and to loosen the epidermis and hairs. These plans, especially the two latter, are apt to injure the quality of the hides.

The *bate*, consists in steeping the haired hides in a solution of pigeon's dung, containing, Mr. Lee says, muriate of ammonia, muriate of soda, &c.; but most probably phosphates of ammonia and lime, with urate of ammonia, and very fermentable animal matter. The dry hides are often subjected first of all to the operation of the fulling-stocks, which opens the pores, but at the same time prepares them for the action of the liming and bate; as also for the introduction of the tanning matter. When the fulling is too violent, the leather is apt to be too limber and thin. Mr. Lee conceives that the liming is injurious, by carrying off more or less of the gelatine and albumen of the skin. High-limed leather is loose, weighs light, and wears out quickly. The subsequent fermentation in the bating aggravates that evil. Another process has therefore been adopted in New York, Maine, New Hampshire, and some parts of Philadelphia, called, but incorrectly, *cool sweating*, which consists in suspending the

hides in a subterranean vault, in a temperature of 50° Fahr., kept perfectly damp, by the trickling of cold spring water from points in the roof. The hides being first soaked, are suspended in this vault from 6 to 12 days, when the hair is well loosened, by the mere softening effect of moisture, without fermentation.

LEATHER, MOROCCO. (*Maroquin*, Fr.; *Saffian*, Germ.) Morocco leather of the finer quality is made from goat-skins tanned with sumach; inferior morocco leather from sheep skins. The goat skins as imported are covered with hair; to remove which they are soaked in water for a certain time, and they are then subjected to the operation called breaking, which consists in scraping them clean and smooth on the flesh side, and they are next steeped in lime pits (milk of lime) for several days, during which period they are *drawn out*, with a hook, from time to time, laid on the side of the pit to drain, and replunged alternately, adding occasionally a little lime, whereby they are eventually deprived of their hair. When this has become sufficiently loose, the skins are taken out one by one, laid on convex beams, the work benches, which stand in an inclined position, resting on a stool at their upper end, at a height convenient for the workman's breast, who scrapes off the hair with a concave steel blade or knife, having a handle at each end. When un haired, the skins are once more soaked in milk of lime for a few days, and then scraped on the flesh side to render it very even. For removing the lime which obstructs their pores, and would impede the tanning process, as well as to open these pores, the skins are steeped in a warm semi-putrid alkaline liquor, made with pigeons' and hens' dung diffused in water. Probably some very weak acid, such as fermented bran water, would answer as well, and not be so offensive to the workmen. (In Germany the skins are first washed in a barrel by a revolving axle and discs.) They are again scraped, and then sewed into bags, the grain outermost, like bladders, leaving a small orifice, into which the neck of a funnel is inserted, and through which is poured a certain quantity of a strong infusion of the sumach; and they are now rendered tight round the orifices, after being filled out with air, like a blown bladder. A parcel of these inflated skins are thrown into a very large tub, containing a weaker infusion of sumach, where they are rolled about in the midst of the liquor, to cause the infusion within to act upon their whole surface, as well as to expose their outsides uniformly to the tanning action of the bath. After a while these bladder skins are taken out of the bath, and piled over each other upon a wooden rack, whereby they undergo such pressure as to force the enclosed infusion to penetrate through their pores, and to bring the tannin of the sumach into intimate contact, and to form a chemical combination with the skin fibres. The tanning is completed by a repetition of the process, of introducing some infusion or decoction into them, blowing them up, and floating them with agitation in the bath. In this way goat skins may be well tanned in the course of one day.

The bags are next undone by removing the sewing, the tanned skins are scraped as before on the carriers' bench, and hung up in the drying loft or shed; they are said now to be "in the crust." They are again moistened and smoothed with a rubbing tool before being subjected to the dyeing operations, in which two skins are applied face to face to confine the dye to one of their surfaces only, for the sake of economising the dyeing materials, which may be of several different colours. The dyed skins are grained by being strongly rubbed with a ball of box wood, finely grooved on its surface.

Preparatory to being dyed, each skin is sewed together edgewise, with the grain on the outside, and it is then mordanted either with a solution of tin, or with alum water. The colour is given by cochineal, of which from 10 to 12 ounces are required for a dozen of skins. The cochineal being boiled in water along with a little tartar or alum for a few minutes, forms a red liquor, which is filtered through a linen cloth, and put into a clean cask. The skins are immersed in this bath, and agitated in it for about half an hour; they are taken out and beaten, and then subjected to a second immersion in the cochineal bath. After being thus dyed, they are rinsed and tanned with Sicilian sumach, at the rate of two pounds for a skin of moderate size. This process is performed in a large tub made of white wood, in the liquor of which the skins are floated like so many bladders, and moved about by manual labour during four hours. They are then taken out, drained, and again subjected to the tanning liquor; the whole process requiring a space of twenty-four hours. The skins are now unstitched, rinsed, filled with beetles, drained, rubbed hard with a copper blade, and lastly hung up to dry.

Some manufacturers brighten the colour by applying to the surface of the skins, in a damp state, a solution of carmine in ammonia with a sponge; others apply a decoction of saffron to enliven the scarlet tint. At Paris the morocco leather is tanned by agitation with a decoction of sumach in large casks made to revolve upon a horizontal axis, like a barrel churn. White galls are sometimes substituted for sumach; a pound being used for a skin. The skins must be finally cleaned with the utmost care.

The black dye is given by applying with the brush a solution of red acetate of iron to the grain side. Blue is communicated by the common cold indigo vat; violets, with a

light blue followed by cochineal red ; green, by Saxon blue followed by a yellow dye, usually made with the chopped roots of the barberry. This plant serves also for yellow. To dye olive, the skins are first passed through a weak solution of green vitriol, and then through the decoction of barberry root, containing a little Saxon blue. Puce colour is communicated by logwood with a little alum ; which may be modified by the addition of a little Brazil wood. In all these cases, whenever the skins are dyed, they should be rinsed, wrung or rather drained, stretched upon a table, then besmeared on the grain side with a film of linseed oil applied by means of a sponge, in order to promote their glossiness when curried, and to prevent them becoming horny by too rapid drying.

The last process in preparing morocco leather is the currying, which brings out the lustre, and restores the original suppleness. This operation is practised in different manners, according to the purpose the skins are to serve. For pocket-books, portfolios, and case-making in general, they must be thinned as much as possible upon the flesh side, moistened slightly, then stretched upon the table, to smooth them ; dried again, moistened, and lastly passed two or three times through the cylinder press in different directions, to produce the crossing of the grain. The skins intended for the shoemaker, the saddler, the bookbinder, &c., require more pliancy, and must be differently curried. After being thinned, they are glazed with a polisher while still moist, and a grain is formed upon the flesh side with the roughened lead plate or grainer of the curriers, called in French *pommelle* ; they are glazed anew to remove the roughness produced by the pommel, and finally grained on the flesh side with a surface of cork applied under a pommel of white wood.

TAWING OF SKINS. (*Megisserie*, Fr. ; *Weisgerberei*, Germ.) The kid, sheep, and lamb skins, are cleaned as has been described under leather. In some factories they receive the tanning power of the submuriate of alumina (from a solution of alum and common salt) in a large barrel-churn apparatus ; in which they are subjected to violent agitation, and thereby take the *aluming* in the course of a few minutes. In other cases, where the yolks of eggs are added to the above solution, the mixture, with the skins, is put into a large tub, and the whole trampled strongly by the naked feet of the operator, till the emulsion of the egg be forced into the pores of the skin. The tawed skins, when dry, are "staked," that is stretched, scraped, and smoothed by friction against the blunt edge of a semi-circular knife, fixed to the top of a short beam of wood set upright. The workman holding the extremities of the skin with both hands, pulls it in all directions forcibly, but skilfully, against the smoothing "stake."

In an entertaining article on tanning in the 11th vol. of the Penny Magazine, at page 215., the following description is given of one of the great tawing establishments of London.

"In the production of 'imitation' kid leather, the skin of lambs is employed ; and for this purpose lamb-skins are imported from the shores of the Mediterranean. They are imported with the wool yet on them ; and as this wool is valuable, the leather manufacturer removes this before the operations on the pelt commence. The wool is of a quality that would be greatly injured by the contact of lime, and therefore a kind of natural fermentation is brought about as a means of loosening the wool from the pelt. At the *Neckinger* establishment of Messrs. Bevington and Co., Bermondsey, one of the buildings presents, on the ground floor, a flight of stone steps, leading down to a range of subterranean vaults or close rooms, into which the lamb-skins are introduced in a wet state, after having been steeped in water, 'broken' on the flesh side, and drained. The temperature of these rooms is nearly the same all the year round, a result obtained by having them excluded as much as possible from the variations of the external atmosphere ; and the result is, that the skins undergo a kind of putrefactive or fermenting process, by which the wool becomes loosened from the pelt. During this chemical change ammonia is evolved in great abundance ; the odour is strong and disagreeable ; a lighted candle, if introduced, would be instantly extinguished, and injurious effects would be perceived by a person remaining long in one of the rooms. Each room is about ten feet square, and is provided with nails and bars whereon to hang the lamb-skins. The doors from all the rooms open into one common passage or vault, and are kept close, except when the skins are inspected. It is a point of much nicety to determine when the fermentation has proceeded to such an extent as to loosen the wool from the pelt ; for if it be allowed to proceed beyond that stage, the pelt itself would become injured."

When the fermentation is completed, generally in about five days, the skins are removed to a beam, and there "slimed," that is scraped on the flesh side, to remove a slimy substance which exudes from the pores. The wool is then taken off, cleaned, and sold to the hatters, for making the bodies of common hats. The stripped pelts are steeped in lime-water for about a week, to kill the grease ; and are next "flushed on the beam." After being placed in a "drench," or a solution of sour bran for some days to

remove the lime and open the pores, the skins are alumed, and subjected to nearly the same processes as the true kid-skins. (See LEATHER.) These Mediterranean lamb skins do not in general measure more than about 20 inches by 12; and each one furnishes leather for two pairs of small gloves. These kinds of leather generally leave the leather-dresser in a white state; but undergo a process of dyeing, softening, "stroking," &c., before being cut up into gloves.

The tanning of one average-sized skin requires about $1\frac{1}{2}$ lbs. of good Sicilian sumach; but for leather which is to receive a bright scarlet dye, from one half to three quarters of a pound of gall-nuts are employed in preference. Inferior goat skins are tanned with a willow bark infusion, in pits, in which they are turned repeatedly, and laid out to drain, as in tanning sole leather. The finest skins for the brightest scarlet are cured with salt, to prevent their receiving damage in the transport, and are dyed before being tanned. This method is practised in Germany and France.

Leather of deer and sheep-skins is prepared with oil, for the purpose of making breeches, &c., and for wash-leather, used in cleaning plate. After they are completely washed, limed, and beamed, as above described, they have their "grain"-surface removed, to give them greater softness and pliability. This removal of the grain is called "frizing," and it is done either with the round edge of a blunt knife, or with pumice-stone. After being freed from the lime by steeping in fermented bran-water, they are pressed as dry as may be, and are then impregnated with cod-oil, by beating with stocks in the trough of a kind of a fulling mill. Previously to the application of the oil, they are usually beat for some time alone to open their substance. The oiled skins are stretched, hung up for some time in the air, then filled with oil as before—a process which is 8 or 9 times repeated. The oil is slowly and evenly poured upon the skins in the trough during the action of the beaters. One hundred skins usually take up in this way from two to three gallons of oil. The filled oiled skins are thrown into large tubs, and left for some time to ferment, and thereby to combine more intimately with the oil. They are lastly subjected to a weak potash lye bath, to strip them of the loosely adhering oil. They are then hung up in the air to dry, and dressed for the market.

The quantity of hides and skins converted into leather yearly in England is almost incredibly large. At Messrs. Bevington's establishment alone there are about 250,000 skins annually converted into leather by the aluming or tawing process; 220,000 by the sumach tanning process; as also a small number by the oil-dressing process. For the importation and exportation of *skins* untanned and tanned, see HIDEs.

Leather and Skins in the Exhibition.—The present class includes a variety of manufacturing processes relating to the commercial preparation of animal substances in the form of leather, skins, fur, hair, and feathers. Until within a recent period, experience rather than science has directed the labours of manufacturers in their operations upon these substances. And at present the rules taught by experience are, in many cases, still pursued in practice, with, however, such modifications as an intelligent comprehension of the operations of the chemical and other philosophical laws put into force in the processes would suggest.

The following sub-classes are recognised in this class: A, leather, as rough and tanned, curried, enamelled, dyed; oil leather, as buckskin, doeskin, &c.; white and alum leather; sheep and skin rugs, parchment and vellum; B, saddlery and harness; C, miscellaneous; D, shink and furs of all descriptions for personal and domestic use; E, feathers, as those of ostrich, marabout, &c.; F, hair, ornamentally and usefully applied.

The localities in which the manufactures concerned in this class are carried on, and from whence articles for exhibition have chiefly been derived, are Bermondsey, where the preparation of leather has been successfully conducted during a very long period, Hull, Swansea, Bristol, Cork, Liverpool, Edinburgh, and Falmouth.

The manufacture of leather has been estimated as only fourth in importance among the national manufactures of Great Britain. A large amount of capital is employed in its production, and the number of artizans and others directly supported by this branch of industry has been taken to amount to nearly a quarter of a million. The total annual value of the leather manufactures is computed at about fourteen millions sterling. It appears probable that in the mere article of boots and shoes, upwards of seven millions sterling are annually expended by the inhabitants of this country. If it be considered that rather more than half the leather produced is thus applied, the remainder is employed in the production of harness, saddlery, gloves, and the multifarious purposes for which leather is applicable. Of late, chemistry has been studied attentively by those dependent upon this branch of industry, and successful results have ensued. A variety of patent processes exist by which the enormous amount of time involved in tanning on the old system is abridged to a surprising extent. With some specimens of leather it has not been unusual to devote eighteen months or upwards to their combination with the native principles of the bark. A few weeks are sufficient, under several of the new

systems, to effect the same object. But it is stated that the leather produced rapidly differs from that produced by the slower process of combination in its durability and solidity. And it is considered by some, that time is an essential element in the manufacture, and that it cannot be advantageously shortened to any considerable extent.

Leather is unquestionably a chemical compound, and this renders it probable that a slow and gradual process of combination between the gelatine of the skin and the tannic acid of the bark may produce a leather to some extent of different properties to that formed by a quicker operation. A very large amount of leather is, however, manufactured by the rapid process, from which it may be concluded that the product possesses great commercial value. A great variety of leathers in all conditions and states of manufacture is exhibited, with instructive series illustrating the peculiarities of different methods of manufacture, according to the difference of the purposes for which the prepared skin is to be afterwards applied.

An extensive and interesting collection of furs is exhibited. Probably the opportunity has never before presented itself for a complete study of this class of manufacture. Furs of the most rare description, devoted only to the use of monarchs, are among these specimens. To the naturalist desirous of ascertaining the genera and species yielding the furs of commerce—a subject on which much conflicting opinion exists,—these objects, which are fully and correctly described in the catalogue of this class, will be highly interesting and instructive. Feathers and hair are also represented by various interesting objects, possessing their peculiar merits and attraction. The number of exhibitors in this class is considerable; but since it includes boots and shoes, and other articles of personal and domestic use in addition to saddlery, &c., the number of persons actually appearing in the capacity of manufacturers is to be distinguished from the proprietors. And, as is the common rule, the class of producers or manufacturers bears only a small proportion to that of proprietors, or, in the commercial sense, vendors of manufactured articles.

Hudson's Bay Company, producers.—Specimens of skins from the Arctic regions, belonging to the Hudson's Bay Company, selected for the Exhibition from their importation of 1851, prepared and arranged by the exhibitors from No. 1. to No. 27.

The immense tracts of country over which the Hudson's Bay Company has control, may be considered as vast hunting-grounds, affording a varied and exhaustless supply of furs. The territorial possessions of this Company cover nearly one-eighth of the habitable globe. Russia is next in order and importance in this respect, but with a different race of animals. The fur produce of North America and the Canadas is also important. As we approach the tropics and the warmer regions, the silky fur with which the animals are clothed in the northern climes disappears, and fur of a totally different character is met with, which, although splendid in appearance, is not adapted for warmth or general use.

TABLE OF IMPORTS AND EXPORTS.

| | Total Importation into England. | Exported. | Consumed in England. |
|------------------|---------------------------------------|-----------|-------------------------|
| Raccoon - - - | 525,000 | 525,000 | none |
| Beaver - - - | 60,000 | 12,000 | 48,000 |
| Chinchilla - - - | 85,000 | 30,000 | 55,000 |
| Bear - - - | 9,500 | 8,000 | 1,500 |
| Fisher - - - | 11,000 | 11,000 | none |
| Fox, red - - - | 50,000 | 50,000 | none |
| " cross - - - | 4,500 | 4,500 | none |
| " silver - - - | 1,000 | 1,000 | none |
| " white - - - | 1,500 | 500 | 1,000 |
| " grey - - - | 20,000 | 18,000 | 2,000 |
| Lynx - - - | 55,000 | 50,000 | 5,000 |
| Martin - - - | 120,000 | 15,000 | 105,000 |
| Mink - - - | 245,000 | 75,000 | 170,000 |
| Musquash - - - | 1,000,000 | 150,000 | 850,000 |
| Otter - - - | 17,500 | 17,500 | none |
| Fur, seal - - - | 15,000 | 12,500 | 2,500 |
| Wolf - - - | 15,000 | 15,000 | none |

EUROPEAN FURS.

| | | | | |
|-------------------------|---|-----------|--------|-----------|
| Martin, stone, and baum | - | 120,000 | 5,000 | 115,000 |
| Squirrel | - | 2,271,258 | 77,160 | 2,194,098 |
| Fitch | - | 65,091 | 28,276 | 36,815 |
| Kolinski | - | 53,410 | 200 | 53,210 |
| Ermine | - | 187,104 | none | 187,104 |

1. Group of black and silver furs (*Vulpis polio*, var. *argentatus*).
2. Group of foxes (*Vulpis fulvo*, var. *decussatus*).
3. Group of red and silver foxes (*Vulpis fulvo*).
4. " white " (*Vulpis lagopus*).
5. " kitt " (*Vulpis velox*).

The black and silver fox is the most valuable of his tribe; they are generally purchased for the Russian and Chinese markets, being highly prized in those countries. The cross and red fox are used by the Chinese, Greeks, Persians, &c., for cloak-linings and for trimming dresses. The white and blue fox is used in this and other countries for ladies' wear. In the sumptuary laws passed in the reign of Henry III., the fox is named with other furs then in use.

7. Group of beaver (*Castor Americanus*).

The beaver in former years was one of the Hudson's Bay Company's most valuable productions; but since its use has been almost entirely discontinued in the manufacture of hats, it has lost much of its value. Experiments have, however, been made, and with prospect of success, to adapt its fine and silky wool to weaving purposes. The skin of the beaver is prepared by a new process, after which the surface is cut by a new and ingenious machine, and the result is a beautiful fur for ladies' wear. It is exported in its prepared state to various parts of Europe and the East.

The rich white wool from the under part of the beaver is largely exported to France.

8. Group of lynx (*Felis Canadianis*).

9. " lynx cat (*Felis rufa*).

Both the above furs, when dyed, were formerly much used. It is still dyed and prepared, and exported in large numbers for the American market. In its natural state, it is a grayish white, with dark spots, and is used by the Chinese, Greeks, Persians, and others for cloaks, linings, facings, &c.; it is very soft, warm, and light. The fur formerly called the luern is the lynx.

21. Group of black bear (*Ursus Americanus*).

22. " brown bear (*Ursus*, var. *Americanus*).

23. " gray bear (*Ursus ferox*).

The large North American black bear is technically termed the army bear, because it is generally used for military purposes in this and other countries, for caps, pistol-holders, rugs, carriage hammer-cloths, sleigh coverings, &c. The fine black cub bears are much sought after in Russia for making shube-linings, coat-linings, trimmings, facings, &c. The other sorts with the large gray bears, for sleigh-coverings and accompaniments, &c. The white polar bear, the supply of which is very limited, is generally made into rugs which are often bordered with the black and gray bear. The brown or Isabella is at the present time used for ladies' wear in America.

301a. *Nicholay, John Aug., & Son*, 82. Oxford Street. Collectors, Importers, Manufacturers, &c. Selected from Canadian importation, with the assistance of C. M. Lampson, Esq.

28. Group of racoon (*Procyon lator*).

The finest racoon furs are produced in North America, and are imported into this country in immense numbers. They are purchased here by the merchants who attend the periodical fur sales, and who dispose of large quantities at the great fair at Leipsic; they are principally used in Russia and throughout Germany, for lining shubes and coats, and are exclusively confined to gentlemen's wear. The dark skins are the choicest and are very valuable.

64. Group of seal, (*Phoca*), Georgia, Shetland Isles, Falkland Isles, Lomar's Island, and Cape.

65. " plucked and prepared seal, natural colour.

66. " plucked and prepared seal, dyed.

67. " Greenland and Newfoundland seal.

68. " Greenland and Newfoundland seal, dyed.

69. " spotted and silver seal.

The seal is an inhabitant of most countries; it is found in the high northern latitudes in immense numbers; ships are purposely fitted for its capture; the oil produced by the animal, together with its skin, render it (connected as it is with the whale fishery)

important to the trader and interesting to the naturalist. The skins are salted and packed in casks, in which state they are sent to this country; they are then sorted and selected for various purposes; those suitable for leather pass into the tanners' hands, and make a beautiful leather, which is used for ladies' shoes. The blue back, the hair and the silver seal are dressed and used in their natural state, and also dyed and exported in large quantities. The fur seal, the supply of which is always small compared with the other kinds, undergoes a process to prepare it for its intended use. It is brought at the present time to a great degree of perfection in this country: when divested of the long, coarse hair (which protects it in its native element) there remains the rich, curly, silky, yellowish down, in which state it was formerly used for travelling caps and other purposes. It is now seldom made use of in that state, but dyed a beautiful Vandyke brown, giving it the appearance of the richest velvet, and is manufactured in every variety of shape and form, as articles of dress for ladies', gentlemen's and children's wear.

South American.—70. Group of chinchilla, Buenos Ayres (*Chinchilla lanigera*).

71. Group of chinchilla, Arica (*Chinchilla lanigera*).

72. Group of bastard chinchilla or Lima (*Chinchilla lanigera*).

The chinchilla is exclusively a South American animal, and was introduced into this country and France about forty years since.

Group of ermine (*Mustela erminea*).

The ermine is produced in most countries, but the best is from Russia, Sweden, and Norway, and is killed in winter when the fur is pure white (except the tail, with its jet black tip), it being in that season in its greatest perfection: in summer and spring it is gray, and of little or no value. It is the weasel of more southern climes. The ermine is the royal fur of Russia, Germany, Spain, Portugal, Italy, &c. In England at the coronation of the sovereign, the minever, as the ermine is styled in heraldic language, is used, being powdered, that is studded with black spots. The spots or powdered bars on the minever capes of the peers and peeresses being in rows, and the number of rows or bars denoting their various degrees of rank; the sovereign alone and the blood royal having the minever of the coronation robes powdered all over, a black spot being inserted in about every square inch of the fur, crimson velvet being used on that occasion. The crown is also adorned with a band of minever, with a single row of spots; the coronets of the peers and peeresses having a similar arrangement. The black spots are made of the black Astracan lamb. On state occasions in the House of Lords, the peers are arrayed in their robes of state, of scarlet cloth and gold lace, with bars or rows of pure minever, more or less according to their degrees of rank, the sovereign alone wearing the royal minever powdered all over. The judges in their robes of office are clad in scarlet and pure ermine. The ermine, with the tail of the animal inserted therein, is used as articles of dress for ladies in every variety of shape and form, according to the dictates of fashion, and also as cloak linings.

The minever can only be worn on state occasions by those who by their rank are entitled to its use, but as an article of fashion for ladies' wear there is no prohibition in force. In the reign of Edward III., furs of ermine were strictly forbidden to be worn by any but the royal family, and its general use is prohibited in Austria at the present time. In mercantile transactions, ermine is always sold by the timber, which consists of forty skins. The minever fur of a former era was the white belly of the gray squirrel.

36. Group of kolinski (*Mustela Sibirica*).

The kolinski or Tartar sable is produced from Russia, belongs to the weasel tribe, and is in colour a bright yellow; it is much used in its natural state and also dyed to imitate the cheaper sables.

37. Group of squirrel, black (*Sciurus niger*).

38. " squirrel, blue (*Sciurus, var. niger*).

39. " squirrel, kasan (*Sciurus, var. Griscus*).

40. " squirrel, red (*Sciurus vulgaris*).

The squirrel abounds in Russia (where it is produced in the greatest perfection) in such immense numbers as would appear almost incredible; the importation from thence to this country alone last year exceeding 2,000,000. The celebrated Weisenfels lining is made from the white part of the dark blue squirrel. A full-sized cloak lining weighs only 25 ounces; it is known as the petit gris. For colder climates, the linings are made from the back or plain gray part of the squirrel, the best having part of the tail left on each skin. Russia produces about 23,000,000 annually.

41. Group of fitah or pole-cat (*Futorius fatidus*).

About 40 years since this fur was more largely used than at present. It is produced in the greatest perfection in this country.

42. Group of Crimea gray lamb.

43. " Ukraine black lamb.

44. Group of Astracan black lamb.
45. " Astracan gray lamb.
46. " Persian black lamb.
47. " Persian gray lamb.
48. " Spanish lamb.
49. " Hungarian lamb.
60. " English lamb.

The grey and black Persian lamb is mostly used for gentlemen's cloak and coat linings, for facings, collars, caps, &c., and also for army purposes. The Astracan lamb is a rich, wavy, glossy, black skin, very short in the fur, having the appearance of beautiful watered silk: in order to obtain this choice skin, it is averred that the parent sheep is destroyed a certain time before the birth of the lamb. The Persian gray and black lamb is covered with very minute curls; this is produced, it is said, by the animal being as soon as born sewn up tightly in a leathern skin, which prevents the curl expanding. The Hungarian lamb is produced in that country in immense numbers; of it the national coat, called the *Juhász Bunda*, is made. In the summer or wet weather the fur or woolly part is worn outside; in winter, when warmth is required, it is reversed: the skin is tanned or dressed in a way peculiar to the country, and decorated and embroidered in accordance with the means and taste of the wearer. In Spain the lamb is used for the well-known characteristic short jacket of that country, which is adorned with filigree silver buttons; the coarser kinds of both colours are used for our cavalry, and is also employed for mounting and bordering skins, as leopards, tigers, &c., for ornamental and domestic purposes. In the reign of Richard II., the sergeant-at-law wore a robe furred inside with white lambekin and a cape of the same.

51. Group of Perewartzki.

52. " Hamster.

The above are from Russia: the former is used by ladies; the latter is made into cloak linings, which are exceedingly light, durable, and cheap.

53. Group of coloured cat.

54. " black cat.
55. " black Dutch.
56. " coloured Dutch.

The cat, properly attended to and bred purposely for its skin, supplies a most useful and durable fur: in Holland it is bred and kept in a confined state till the fur is in its greatest perfection, and is fed entirely on fish. In other countries, and especially in our own, it is produced in large numbers. The wild cat is much larger and longer in the fur, and is met with in extensive forests, particularly in Hungary: the colour is gray, spotted with black, and its softness and durability render it suitable for cloak and coat linings, for which purposes it is much used. The black species is also much in request, and similarly used, and, with the spotted and striped varieties, is made into wrappers for open carriages, sleigh coverings, and railway travelling.

92. Group of dyed lynx, see No. 8.

94. " penguin (*Speniscus optenodytes*).
95. " grebe (*Podiceps cristata*).

The grebe is an aquatic bird, inhabiting most of the large lakes in Europe. The choicest specimens are from Geneva, Italy, and Holland. The feathers are of rich white, having the appearance of polished silver, the plumage on the outer edge of the skin being a rich dark brown; it is used by ladies and forms a beautiful article of dress, and is worn as trimmings for the trains of court and drawing room dresses, for muffs, cuffs, boars, &c. It is very durable; the exquisite smoothness of its feathers prevents its soiling with wear.

96. Specimen of swan feathers.

97. " goose feathers.
98. " eider down.

The bird from which the down is taken is found in large numbers in Iceland, Norway, Sweden, &c.; its colour is dark grey, and its elasticity, lightness, and resistance to wet, are prominent amongst its other advantages: it is used for the inside stuffing of muffs. On the continent the well known eider down quilts are largely used.

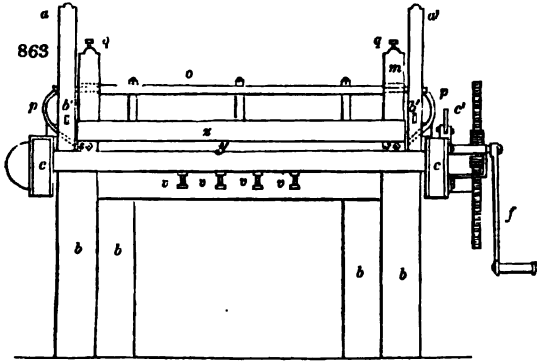
99—115. Suits of Russia sable; Hudson's Bay sable; sable tail, mink; chinchilla; grebe; sea otter; Siberian squirrel, with tails; kolinski; minever; ermine; moleskin; natural beaver; dyed beaver; seal; swan; goose down.

The down of the goose is manufactured by being sewn on textile fabrics. It is a specimen of Irish industry, and has been patronised and sold in England extensively for the benefit of the Irish female poor, by whom it has been made up. The price, compared with the true swan's down, is very moderate. Being sewn upon cloth, it can be washed.

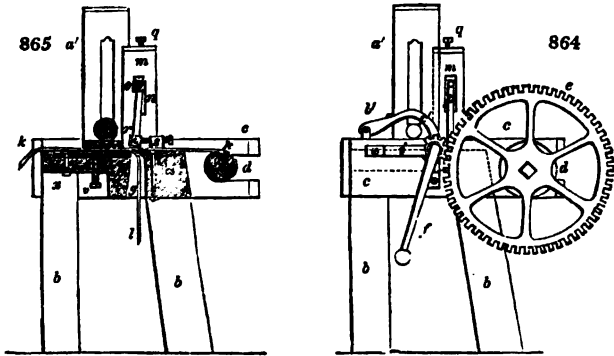
LEATHER SPLITTING. This operation is employed sometimes upon certain

sorts of leather for gloves, for bookbinders, sheath-makers, and always to give a uniform thickness to the leather destined for the cotton and wool card-makers.

Figs. 863, 864, 865, 866. represent a well contrived machine for that purpose; of which *fig. 863.* shows the front view, *fig. 864.* a view from the left side, *fig. 866.* a ground plan, and *fig. 865.* a vertical section across the machine. *a* is a strong table, furnished with four legs *b*, which to the right and left hand bears two horizontal pieces *c*. Each of



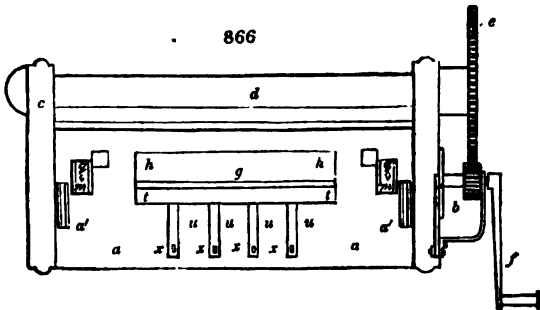
these pieces is cut out in front, so as to form in its substance a half-round fork, that receives a cylinder *d*, carrying on its end a toothed spur-wheel *e*. Motion is com-



municated to the wheel by means of the handle *f*, upon whose axis the pinion *i*, is fixed, working into the wheel *d*, made fast to the end of the cylinder round which the leather is rolled. The leather is fixed at one of its ends or edges to the cylinder, either with a wedge pressed into a groove, or by a movable segment of the cylinder itself.

The table, *a*, is cut out lengthwise with a slot, that is widened below, as shown in *fig. 865.*

The knife *h* (*figs. 865. and 866.*) is fixed flat upon the table with screw bolts, whose



heads are countersunk into the table, and secured with taps beneath (*fig. 865.*) the edge of the knife being placed horizontally over the opening, and parallel with it.

In *fig. 865.* the leather, *k*, is shown advancing against the knife, getting split, and has a portion coiled round the cylinder, which is made to revolve in proportion as the leather is cleft. The upper portion of the leather is rolled upon the cylinder *d*, while the under half, *l*, falls through the oblong opening upon the ground.

In regulating the thickness of the split leather, the two supports, *m*, act; they are made fast to the table *a* (one on each side of the knife), and are mortised into the table by two tenons secured beneath. These supports are furnished near their tops with keyed slots, by means of which the horizontal iron rod *o* (*figs. 863. 865.*) is secured, and outside of the uprights they press upon the springs *p p*, which tend to raise the rod, *o*, in its two end slots; but the adjusting screws *q*, which pass down through the tops of the supports into the mortise *n* (*fig. 865.*), and press upon the upper half of the divided tenon, counteract the springs, and accordingly keep the rod, *o*, exactly at any desired height or level. The iron rod, *o*, carries another iron bar, *r*, beneath it, parallel and also rectangular, *fig. 865.* This lower bar, which is rounded at its under face, lies upon and presses the leather, by the action of two screws, which pass through two upright pieces *s* (*figs. 863. and 865.*) made fast to the table; thus the iron bar, *r*, may be made to press forwards the edge of the knife, and it may be adjusted in its degree of pressure, according to the desired thickness of the leaf of split leather that passes through under it.

Fig. 865. shows that the slant or obliquity of the knife is directed downwards, over one of the edges of the oblong opening *g*; the other edge of this opening is provided with an iron plate *t* (*figs. 865. 866.*), which serves to guide the blade in cutting the leather to the proper depth. For this purpose the plate is made adjustable by means of the four springs *u* (*figs. 865. 866.*), let into the table, which press it downwards. Four screws, *v*, pass down through the table, each belonging to its respective springs *u*, and by means of these screws the plate, *t*, may be raised in any desired degree. Each of the screws, *u*, has besides a small rectangular notch through which a screw bolt, *x*, passes, by which the spring is made fast to the table. Thus also the plate, *t*, may be made to approach to or recede from the knife.

y, in *figs. 863. and 865.* is a flat board, laid upon the leather a little behind the edge of the plate *t*; this board is pressed by the cylinder *z*, that lies upon it, and whose tenons rest in mortises cut out in the two supports *a'*. The cylinder, *z*, is held in its position by a wedge or pin *b* (*figs. 863. and 864.*), which passes through the supports. When the leather has been split, these pins are removed, and the cylinder rises then by means of two counter weights, not shown in the figures.

The operation of the machine is as follows; — The edge or end of the leather being secured to the cylinder *d*, the leather itself having the direction upon the table, shown in *fig. 865.* and the bar, *r*, its proper position over the knife, the edge begins to enter in this position into the leather, while the cylinder, *d*, is moved by the handle or winch, and the piece gets split betwixt the blade and the roller *d*. When the other end of the leather, *k*, advances to the knife, there is, consequently, one half of the leather split; the skin is to be then rolled off the cylinder *d*; it is turned; the already split half, or the end of the leather *k*, is made fast into the wood of the cylinder, and the other half is next split; while the knife now acts from below, in an opposite direction to what it did at first.

That the unrolling of the leather from the cylinder, *d*, may not be obstructed by the pinion *i*, the stop-wedge *e* (*figs. 863. 864.*) is removed from the teeth. In the process of splitting, the grain side of the leather is uppermost, and is therefore cut of an uniform thickness, but the under side varies in thickness with the inequality of the skin.

The quantity of leather gloves of Foreign production exported in 1850, was 401,009 pairs, and in 1851, 107,925 pairs. See HIDES.

Exports of Leather of British Produce and Manufacture.

| | Quantities. | | Declared Value. | |
|-------------------------------|-------------|-----------|-----------------|---------|
| | 1850. | 1851. | £ | £ |
| Leather, unwrought, cwts. | 32,205 | 25,525 | 181,737 | 152,070 |
| Wrought, viz. gloves, lbs. | 31,124 | 27,141 | 18,821 | 19,781 |
| Of other sorts, lbs. | 1,619,463 | 1,625,565 | 284,347 | 288,543 |
| Saddlery and harness, value £ | — | — | 123,960 | 138,168 |

LEDUM PALUSTRE. This plant is employed in Russia to tan the skins of goats, calves, and sheep, into a reddish leather of an agreeable smell; as also in the preparation of the oil of birch, for making what is commonly called Russia leather.

LEGUMINE, is the name of a vegeto-alkali supposed to exist in leguminous plants.

LEMONS. See CITRIC ACID, and OILS, ESSENTIAL.

LEVIGATION, is the mechanical process whereby hard substances are reduced to a very fine powder.

LEUCITE, is a hard Vesuvian mineral, consisting of silica, 54; alumina, 23; potash, 23.

LEUCINE, is a white crystalline substance produced by acting upon flesh with sulphuric acid.

LEWIS, is the name of one kind of shears used in cropping woollen cloth.

LIAS, is a fine-grained argillaceous limestone, whose geological position is under the oolite; it is the proper lithographic stone.

LIBAVIUS, LIQUOR OF, is the bichloride of tin, prepared by dissolving that metal with the aid of heat, in *aqua regia*, or by passing chlorine gas through a solution of muriate of tin till no more gas be absorbed, evaporating the solution, and setting it aside to crystallize. The anhydrous bichloride is best prepared by mixing four parts of corrosive sublimate with one part of tin, previously amalgamated with just so much mercury as to render it pulverizable; and by distilling this mixture with a gentle heat. A colourless fluid, the dry bichloride of tin, or the proper fuming liquor of Libavius, comes over. When it is mixed with one-third of its weight of water it becomes solid. The first bichloride of tin is used in calico-printing.

LICHEN. See ARCHIL.

LIGNEOUS MATTER, is vegetable fibre. See FIBROUS MATTER.

LIGNITE, is one of the most recent geological formations, being the carbonaceous remains of forest trees. From this substance, as found in the neighbourhood of Cologne, the brown colours, called *umber* and *earth of Cologne*, are prepared.

LILAC DYE. See CALICO-PRINTING AND DYEING.

LIMESTONE (*Calcaire*, Fr.; *Kalkstein*, Germ.); may be classed under the following heads:—

1. *Calcareous spar* occurs in colourless crystals or crystalline masses; dissolves with effervescence in muriatic acid; is scratched by soft iron, but not by the nail; specific gravity 2.7; loses 46 per cent. by the expulsion of carbonic acid, and calcines into quicklime.

2. *Calcsinter, or stalactitic carbonate of lime*, called also concretionary limestone, because formed of zones more or less undulated, and nearly parallel. These zones have a fibrous structure, arising from the successive deposits of the crystalline limestone from its solvent water. The long conical pieces called stalactites, show fibres converging to the axis. The tubercular consists of irregular lumps often sprinkled over with small crystals, and associated so as to exhibit the appearance of cauliflower. The stratiform, commonly called stalagmite, or alabaster limestone, represents zones not concentric, but spread out, waving, and parallel; its texture is sometimes lamellar, and sometimes fibrous. These waving strata are distinguishable from one another by their different densities, and by their degrees of translucency. This stalagmitic mass bears the name of oriental alabaster, when it is reddish-yellow with distinct zones, and is susceptible of a fine polish. Stalactites are formed in the large excavations of calcareous rocks. The water percolating down through them, and dropping from the roofs of the caverns, is usually charged with carbonate of lime held in suspension by an excess of carbonic acid. The exposure to air, the motion, and the consequent diminution of pressure, cause the precipitation of the carbonate of lime in the solid state. Each drop of water, on falling through the vault, abandons a small film of limestone, which enlarges by degrees, and forms either a cylinder or solid mass. This alabaster differs from marble in its parallel and waving layers, and its faint degree of transparency.

This alabaster serves for the decoration of public buildings, and is occasionally introduced into certain pieces of furniture. The fine Egyptian alabaster was anciently brought from the mountains of the Thebaid, between the Nile and the Red Sea, near a town called Alabastron, whence probably the name. Very fine red alabaster, of great hardness, was found at one time in the quarries of Montmartre, but the stock was soon exhausted.

The incrusting concretionary limestone differs little from the preceding except in the rapidity of its formation, and in being moulded upon some body whose shape it assumes. These deposits from calcareous springs form equally on vegetable bodies, on stones, metals, within pipes of cast iron, wood, or lead. The incrustations on vegetable and animal substances are vulgarly called petrifications, as the organic fibres are replaced by stone. One of the most curious springs of this nature is at the baths of Saint Philip, in Tuscany, where the water flows, in almost a boiling state, over an enormous mass of alabaster which it has produced. The carbonate of lime seems to be held in solution here by sulphuretted hydrogen, which flies off when the water issues to the day. Dr. Vegny has taken advantage of this property of the spring, to obtain basso-relievo figures of great whiteness and solidity. He makes use of sulphur moulds.

Calcareous tuf consists of similar incrustations made by petrifying rivulets running over mud, sand, vegetable remains, &c. It is porous, even cellular, somewhat soft, impure, and of a dirty gray colour. Its surface is wavy, rough, and irregular. These incrustations or deposits are, however, sometimes so abundant, and the resulting stony matters so hard, that buildings may be constructed with them. The stone with which the town of Pasti, in Italy, is built has been called *pipe-stone* by the Italians; and it has apparently derived its origin from incrustations upon large reeds.

The *travertino*, which served to construct all the monuments of Rome, appears to have been formed by the deposits of the Anio and the solfatara of Tivoli. The temples of Paestum, which are of extreme antiquity, have been built with a *travertino* formed by the sediment of the waters which still flow in this territory. All these stones acquire great hardness in the air, and M. de Breislak thinks that it is to the happy union of travertino and pouzzolana in the same spot, that the monuments of Rome owe their great solidity.

Spongy limestones, usually called *Agaric mineral*, stone marrow, &c., belongs to this kind of formation. It has a very white colour, a very fine grain, is soft to the touch, very tender, and light enough to float for an instant on water. It occurs in rather thin layers, in the crevices of calcareous rocks, and is so common in Switzerland as to be employed for whitening houses.

3. *Compact limestone*, is of a grain more or less fine, does not polish, nor afford large blocks free from fissures, has a conchoidal, or uneven scaly fracture. Colours very various. Its varieties are; *a*, The *sub-lamellar*, compact, with some appearance of a foliated texture. *b*, *Compact fine-grained limestone*, the *zechstein* of the Germans, to which M. Brongniart refers the lithographic stone in his classification of rocks (*Dictionnaire des Sciences Naturelles*), but the English geologists place the locality of the famous lithographic quarry of Solenhofen much higher in the plane of secondary superposition. Its fracture is conchoidal; colour from gray to whitish; *c*, *Compact common limestone*. Grain of middle size; earthy aspect; uneven fracture; perfectly opaque; colour, whitish to pale gray, yellow, or reddish. The limestones of the Jura formation are referred to this head, as well as most of those interspersed among the coal strata. *d*, The *coarse compact*, or *Cornbrash*; texture somewhat open, earthy aspect, rough to the touch, ragged fracture, colour yellow, gray, or dirty red. *e*, *Compact cellular*, the *Rauchekalk* and *Holekalk* of the Germans, on account of the numerous holes or caverns distributed through it.

4. *Oolite or roe-stone*.—It consists of spherical grains of various size, from a millet seed to a pea, or even an egg; texture compact; fracture even; colours, whitish, yellow, gray, reddish, brownish. The larger balls have almost always a foreign body for their centre or nucleus.

5. *Chalk*; texture earthy; grains fine, tender, friable; colours white, grayish, or pale yellowish.

6. *Coarse-grained limestone*; an earthy texture, in large particles, often loose; fracture foliated, uneven; colour pale and dirty yellow. Coarse *lias* has been referred to this head.

7. *Marly limestone*; lake and fresh-water limestone formation; texture fine-grained, more or less dense; apt to crumble down in the air; colour white or pale yellow; fracture rough-grained, sometimes conchoidal; somewhat tenacious. Texture occasionally cavernous; with cylindrical winding cavities. This true limestone must not be confounded with lime-marl, composed of calcareous matter and clay.

8. *Siliceous limestone*; of a compact texture; scratching steel, and scratched by it; leaves a siliceous residuum after the action of muriatic acid.

9. *Calp*; texture compact; fine-grained; schistose structure; hard, as the preceding; not burning into quicklime, affording to dilute muriatic acid a copious residuum of clay and silica; colour blackish; found in beds in the transition district near Dublin.

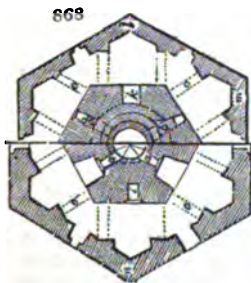
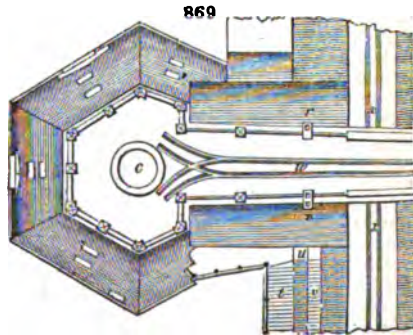
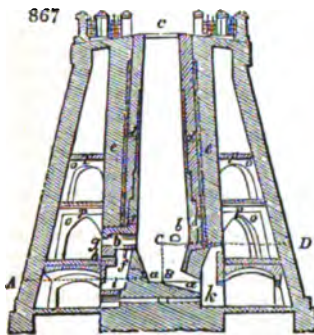
10. *Lucullite* or *stinkstone*; texture compact or sub-lamellar, colour grayish; emits the smell of sulphuretted hydrogen by friction or a blow. It occurs at Assynt, in Sutherlandshire; in Derbyshire; counties of Kilkenny, Cork, and Galway.

11. *Bituminous limestone*; black or blackish colour; diffusing by the action of fire a bituminous odour, and becoming white.

Of all common limestones the purity may most readily be determined by the quantity of carbonic acid which is evolved during their solution in dilute nitric or muriatic acid. Perfect carbonate of lime loses in this way 46 per cent.; and if any particular limestone loses only 23 per cent., we may infer that it contains only one half its weight of calcareous carbonate. This method is equally applicable to *marls*, which are mixtures in various proportions of carbonate of lime, clay, and sand, and may all be recognized by their effervescing with acids.

The chief use of calcareous stones is for procuring quicklime by calcination in proper

furnaces; and they are all adapted to this purpose, provided they are not mixed with too large a proportion of sand and ferruginous clay, whereby they acquire a vitrescent texture in a high heat, and will not burn into lime. Limestone used to be calcined in a very rude kiln, formed by enclosing a circular space of 10 or 15 feet diameter, by rude stone walls 4 or 5 feet high, and filling the cylindrical cavity with alternate layers of turf or coal and limestone broken into moderate pieces. A bed of brushwood was usually placed at the bottom, to facilitate the kindling of the kiln. Whenever the combustion was fairly commenced, the top, piled into a conical form, was covered in with sods, to render the calcination slow and regular. This method being found relatively inconvenient and ineffectual, was succeeded by a permanent kiln built of stones or brick-work, in the shape of a truncated cone with the narrow end undermost, and closed at bottom by an iron grate. Into this kiln, the fuel and limestone were introduced at the top in alternate layers, beginning of course with the former; and the charge was either allowed to burn out, when the lime was altogether removed at a door near the bottom, or the kiln was successively fed with fresh materials, in alternate beds, as the former supply sunk down by the calcination, while the thoroughly burnt lime at the bottom was successively raked out by a side door immediately above the grate. The interior of the lime kiln has been changed of late years from the conical to the elliptical form; and probably the best is that of an egg placed with its narrow end undermost, and truncated both above and below; the ground plot or bottom of the kiln being compressed so as to give an elliptical section, with an *eye* or draft-hole towards each end of that ellipse. A kiln thus arched in above gives a reverberatory heat to the upper materials, and also favours their falling freely down in proportion as the finished lime is raked out below; advantages which the conical form does not afford. The size of the draft-ways for extracting the quicklime, should be proportionate to the size of the kiln, in order to admit a sufficient current of air to ascend with the smoke and flame, which is found to facilitate the extrication of the carbonic acid. The kilns are called *perpetual*, because the operation is carried on continuously as long as the building lasts; and *draw-kilns*, from the mode of discharging them by raking out the lime into carts placed against the draft-ways. Three bushels of calcined limestone, or lime-shells, are produced on an average for every bushel of coals consumed. Such kilns should be built up against the face of a cliff, so that easy access may be gained to the mouth for charging, by making a sloping cart road to the top of the bank.



Figs. 167, 868, 869, 870, represent the *lime-kiln* of Rüdersdorf near Berlin, upon the continuous plan, excellently constructed for economizing fuel. It is triple, and yields a threefold product. Fig. 869. is a view of it as seen from above; fig. 870., the elevation and general appearance of one side; fig. 867. a vertical section, and fig. 868. the ground plan in the line Δ s c n of fig. 867. The inner shaft fig. 868. has the form of two truncated cones, with their larger circular ends applied to each other; it has the greatest width at the level of the fire-door *b*, where it is 8 feet in diameter; it is narrower below at the discharge door, and at the top orifice, where it is about 6 feet in diameter. The interior wall *d*, of the upper shaft is built with hewn stones, to the height of 38 feet, and below that for 25 feet, with fire-bricks *d' d'*, laid stepwise. This inner wall is surrounded with a mantle *e*, of limestone, but between the two there is a small vacant space of a few inches filled with ashes, in order to allow of the expansion of the interior with heat taking place without shattering the mass of the building.

The fire-grate, *b*, consists of fire-tiles, which at the middle, where the single pieces press together, lie upon an arched support *f*. The fire-door is also arched, and is secured by fire-tiles. *g* is the iron door in front of that orifice. The tiles which form the grate have 3 or 4 slits of an inch wide for admitting the air, which enters through the canal *h*. The under part of the shaft from the fire to the hearth is 7 feet, and the outer enclosing wall is constructed of limestone, the lining being of fire-bricks. Here are the ash-pit *i*, the discharge outlet *a*, and the canal *k*, in front of the outlet. Each ash-pit is shut with an iron door, which is opened only when the space *i* becomes filled with ashes. These indeed are allowed to remain till they get cool enough to be removed without inconvenience.

The discharge outlets are also furnished with iron doors, which are opened only for taking out the lime, and are carefully luted with loam during the burning. The outer walls *l m n* of the kiln, are not essentially necessary, but convenient, because they afford room for the lime to lie in the lower floor, and the fuel in the second. The several stories are formed of groined arches *o*, and platforms *p*, covered over with limestone slabs. In the third and fourth stories the workmen lodge at night. See fig. 870. Some enter their apartments by the upper door *q*; others by the lower door *s*. *r* is one of the chimneys for the several fireplaces of the workmen. *z, u, v* are stairs.

As the limestone is introduced at top, the mouth of the kiln is surrounded with a strong iron balustrade to prevent the danger of the people tumbling in. The platform is laid with rails *w*, for the waggons of limestone, drawn by horses, to run upon. *x* is another railway, leading to another kiln. Such kilns are named after the number of their fire-doors, single, twofold, threefold, fourfold, &c.; from three to five being the most usual. The outer form of the kiln also is determined by the number of the furnaces; being a truncated pyramid of equal sides; and in the middle of each alternate side there is a fireplace, and a discharge outlet. A cubic foot of limestone requires for burning, one and five-twelfths of a cubic foot of wood, and one and a half of turf.

When the kiln is to be set in action, it is filled with rough limestones, to the height *c n*, or to the level of the firing; a wood fire is kindled in *a*, and kept up till the lime is calcined. Upon this mass of quicklime, a fresh quantity of limestones is introduced, not thrown in at the mouth, but let down in buckets, till the kiln be quite full; while over the top a cone of limestones is piled up, about 4 feet high. A turf-fire is now kindled in the furnaces *b*. Whenever the upper stones are well calcined, the lime under the fire-level is taken out, the superior column falls in, a new cone is piled up, and the process goes on thus without interruption, and without the necessity of once putting a fire into *a*; for in the space *c a*, the lime must be always well calcined. The discharge of lime takes place every 12 hours, and it amounts at each time in a threefold kiln, to from 20 to 24 Prussian *tonnes* of 6 imperial bushels each; or to 180 bushels imperial upon the average. It is found by experience that fresh-broken limestone which contains a little moisture, calcines more readily than what has been dried by exposure for some time to the air; in consequence of the vapour of water promoting the escape of the carbonic acid gas; a fact well exemplified in distilling essential oils, as oil of turpentine and naphtha, which come over with the steam of water, at upwards of 100° Fahr. below their natural term of ebullition. Six bushels of Rüdersdorf quicklime weigh from 280 to 306 pounds.

When coals are used for fuel in a well-constructed perpetual or draw-kiln, about 1 measure of them should suffice for 4 or 5 of limestone.

The most extensive employment of quicklime is in agriculture, on which subject instructive details are given in *Lowdon's Encyclopædias of Agriculture and Gardening*.

Quicklime is employed in a multitude of preparations subservient to the arts; for clarifying the juice of the sugar-cane and the beet-root; for purifying coal gas; for rendering the potash and soda of commerce caustic in the soap manufacture, and in the bleaching of linen and cotton; for purifying animal matters before dissolving out their gelatine; for clearing hides of their hair in tanneries; for extracting the pure volatile alkali from muriate or sulphate of ammonia; for rendering confined portions of air

very dry ; for stopping the leakage of stone reservoirs, when mixed with clay and thrown into the water ; for making a powerful lute with white of egg or serum of blood ; for preparing a depilatory pomade with sulphuret of arsenic, &c. Lime water is used in medicine, and quicklime is of general use in chemical researches. Next to agriculture the most extensive application of quicklime is to MORTAR-CEMENTS, which see.

LINEN. See **FLAX**, and **TEXTILE FABRICS**.

LINEN distinguished from cotton.—Cotton may be distinguished from linen or flax by immersing the former, well washed and dried, for about a minute in strong sulphuric acid. It is then to be withdrawn and washed with water containing a little alkali. The cotton will dissolve as a gummy mass, while the linen will retain its thready texture.

LINSEED (*Grains de lin*, Fr. ; *Leinsame*, Germ.) ; contains in its dry state, 11·265 of oil ; 0·146 of wax ; 2·488 of a soft resin ; 0·550 of a colouring resinous matter ; 0·926 of a yellowish substance analogous to tannin ; 6·154 of gum ; 15·12 of vegetable mucilage ; 1·48 of starch ; 2·932 of gluten ; 2·782 of albumine ; 10·884 of saccharine extractive ; 44·382 of envelopes, including some vegetable mucilage. It contains also free acetic acid ; some acetate, sulphate, and muriate of potash, phosphate and sulphate of lime ; phosphate of magnesia ; and silica. See **OILS**, **UNCRUOUS**.

LINSEED AND FLAXSEED. Imported, for home consumption, in 1850, 608,984 quarters ; in 1851, 630,471 qrs. ; duty free.

LINSEED OIL, *drying without heat*. When linseed oil is carefully agitated with vinegar of lead (tribasic acetate of lead) and the mixture allowed to clear by settling, a copious white cloudy precipitate forms, containing oxide of lead, whilst the raw oil is converted into a drying oil of a pale straw colour, forming an excellent varnish, which, when applied in thin layers, dries perfectly in twenty-four hours. It contains from four to five per cent. of oxide of lead in solution. The following proportions appear to be the most advantageous for its preparations.

In a bottle containing 4½ pints of rain water, 18 ounces of neutral acetate of lead are placed, and when the solution is complete, 18 ounces of litharge in a very fine powder are added ; the whole is then allowed to stand in a moderately warm place, frequently agitating it to assist the solution of the litharge. This solution may be considered as complete when no more small scales are apparent. The deposit of a shining white colour (sexbasic acetate of lead) may be separated by filtration. This conversion of the neutral acetate of lead into vinegar of lead, by means of litharge and water, is effected in about a quarter of an hour, if the mixture be heated to ebullition. When heat is not applied, the process will usually take three or four days. The solution of vinegar of lead, or tribasic acetate of lead, thus formed, is sufficient for the preparation of 22 lbs. of drying oil. For this purpose, the solution is diluted with an equal volume of rain water, and to it is gradually added, with constant agitation, 22 lbs. of oil, with which 18 ounces of litharge have previously been mixed.

When the points of contact between the lead solution and the oil have been frequently renewed by agitation of the mixture three or four times a day, and the mixture allowed to settle in a warm place, the limpid straw-coloured oil rises to the surface, leaving a copious whitish deposit. The watery solution rendered clear by filtration, contains intact all the acetate of lead first employed, and may be used in the next operation, after the addition to it as before of 18 ounces of litharge.

By filtration through paper or cotton the oil may be obtained as limpid as water and by exposure to the light of the sun it may also be bleached.

Should a drying oil be required absolutely free from lead, it may be obtained by the addition of dilute sulphuric acid to the above, when, on being allowed to stand, a deposit of sulphate of lead will take place, and the clear oil may be obtained free from all trace of lead.

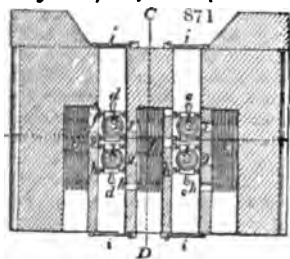
LINT for Surgery, has been made the subject of a patent by Mr. Thomas Ross, of Coleman Street, which consists in the employment of peculiarly constructed scrapers for braiding the surface of the linen cloth, and producing a pile or nap upon it. The scrapers are worked by a rotary motion.

Instead of rotary scrapers, a reciprocating pendulous movement is sometimes applied to a single scraper. Chisel-formed blades are claimed by the patentee as scrapers for raising the pile, by working with the bevel edges forwards, so as to scrape and not to cut the fabric. He has in the rotary form a ledge or bed concentric with the axis of the scraper, which he also claims ; both of which seem to be serviceable. The details and figures may be seen in *Newton's Journal*, xxxvii. 301.

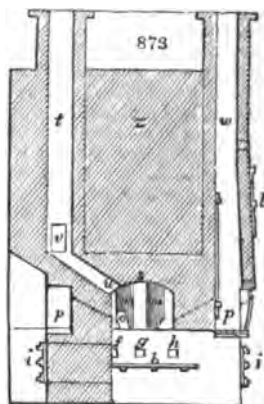
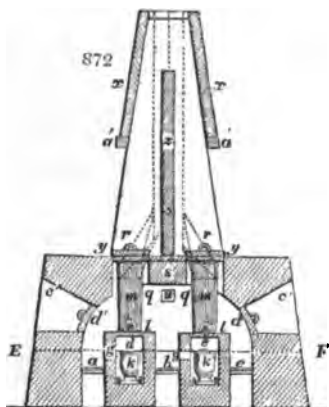
LIQUATION (Eng. and Fr. ; *Saigerung*, Germ.) ; is the process of sweating out, by a regulated heat from an alloy an easily fusible metal from the interstices of a metal difficult of fusion. Lead and antimony are the metals most commonly subjected to liquation ; the former for the purpose of carrying off by a superior affinity the silver

present in any complex alloy, a subject discussed under *SILVER*; the latter will be considered here, as referred to from the article *ANTIMONY*.

Figs. 871, 872, 173. represent the celebrated antimonial liquation furnaces of Malboac,



in the department of Ardèche, in France. *Fig. 871* is a ground plan taken at the level of the draught holes *g g*, *fig. 872*, and of the dotted line *z r*; *fig. 872* is a vertical section through the dotted line *a n*, of *fig. 871*.; and *fig. 873* is a vertical section through the dotted line *c d* of *fig. 871*. In the three figures, the same letters denote like objects. *a, b, c* are three grates upon the same level above the floor of the works, $4\frac{1}{2}$ feet long, by $10\frac{1}{2}$ inches broad; between which are two rectangular galleries, *d e*, which pass transversely through the whole furnace, and lie at a level of 12 inches above the ground. They



are separated by two walls from the three fire places. The walls have three openings, *f, g, h*, alternately placed for the flames to play through. The ends of these galleries are shut in with iron doors *i, i*, containing peep holes. In each gallery are two conical cast-iron crucibles *k, h*, into which the *liquating* sulphuret of antimony drops. Their height is from 12 to 14 inches; the width of the mouth is 10 inches, that of the bottom is 6, and the thickness four-tenths of an inch. They are coated over with fire-clay, to prevent the sulphuret from acting upon them; and they stand upon cast-iron pedestals with projecting ears, to facilitate their removal from the gallery or platform. Both of these galleries are lined with tiles of fire-clay *l l*, which also serve as supports to the vertical liquation tubes *m m*, made of the same clay. The tiles are somewhat curved towards the middle, for the purpose of receiving the lower ends of these tubes, and have a small hole at *n*, through which the liquid sulphuret flows down into the crucible.

The liquation tubes are conical, the internal diameter at top being 10 inches, at bottom 8; the length fully 40 inches, and the thickness six-tenths of an inch. They have at their lower ends notches or slits, *a*, *fig. 873*., from 3 to 5 inches long, which look outwards, to make them accessible from the front and back part of the furnaces through small conical openings *p p*, in the walls. These are closed during the operation with clay stoppers, and are opened only when the gangue, rubbish, and cinders are to be raked out. The liquation tubes pass across the arch of the furnace *q q*, the space of the arch being wider than the tubes; they are shut in at top with fire-covers *r r*. *s s*, the middle part of the arch, immediately under the middle grate, is barrel-shaped, so that both arches are abutted together. The flames, after playing round about the sides of the liquation tubes, pass off through three openings and flues into the chimney *t*, about 13 feet high; *u*, being the one opening, and *v*, the two others, which are provided with register plates. In front of the furnace is a smoke flue *w*, to carry off the sulphureous vapours exhaled during the clearing out of the rubbish and slag; another *x*, begins over *y*, at the top of the tubes; a wall *x*, separates the smoke flue into halves, so that the workmen upon the one side may not be incommoded by the fumes of the other. This wall connects at the same time the front flue *w* with the chimney *t*. *a' a'* and *b' b'* are iron and wooden bearer beams and rods for strengthening the smoke-flue. *c' c'*

are arches upon both sides of the furnace, which become narrower from without inwards, and are closed with well-fitted plates *d' d'*. They serve, in particular circumstances, to allow the interior to be inspected, and to see if either of the liquation furnaces be out of order.

Each tube being charged with about 500 lbs. of the antimonial ore, previously warmed upon the roof of the furnace, in a short time the sulphuret of a blue colour begins to flow out. Whenever the liquation ceases, the cinders are raked out by the side openings, and the tubes are charged afresh. The luted iron crucibles are suffered to become three-fourths full, are then drawn out from the galleries, left to cool, and emptied. The ingots weigh about 85 pounds. The charging is renewed every three hours, and, when the process is in good train, 100 lbs. of sulphuret of antimony are obtained every hour. The average duration of the tubes is 3 weeks, though in some cases it may be 40 days. The product from the ore is from 40 to 50 per cent. The above plan of operation is remarkable for the small consumption of fuel, the economy of labour, and the complete exhaustion of the ore.

LIQUEURS, LIQUORISTE; names given by the French to liquors compounded of alcohol, water, sugar, and different aromatic substances; and to the person who compounds them. I shall insert here a few of their most approved recipes.

Infusion of the peels of fruits.—The outer skin pared off with a sharp knife, is to be dropped into a hard glazed jar, containing alcohol of 34° B., diluted with half its bulk of water, and the whole is to be transferred into well-corked carboys. After an infusion of six weeks, with occasional agitation, the aromatized spirit is to be distilled off. In this way are prepared the liquors of cedrat, lemons, oranges, *limettes* (a sort of sweet lemon), *poncires* (the large citron), bergamots, &c.

Infusion of aromatic seeds.—These must be pounded, put into a carboy, along with alcohol diluted as above, infused with agitation for six weeks, and then distilled.

Infusion of aromatic woods are made in the same way.

The liquorist should not bring his infusions and tinctures into the market till six months after their distillation.

Liqueurs have different titles, according to their mode of fabrication.

Thus *waters* are liquors apparently devoid of viscosity; *creams* and *oils* possess it in a high degree.

Water of cedrat, is made by dissolving six pounds of sugar in seven quarts of water; adding two quarts of spirit of cedrat, and one of spirit of citron. Boil the whole for a minute, and filter hot through a proper bag. Set it for a considerable time aside in a corked carboy, before it be bottled.

Oil or cream of cedrat.—Take eight quarts of river water, two of spirit of cedrat, one of spirit of citron, and as much rich syrup as is necessary to give the mixture an oily consistence. Stir it well and set it aside in carboys. Should it be at all clouded, it must be filtered till it be perfectly pellucid.

Balm of Moluca, is made by infusing for ten days, in a carboy capable of holding fully four gallons, 10 pounds of spirits of 18° B., 4 pounds of white sugar, 4 pounds of river water, 4 drachms of pounded cloves, and 48 grains of pounded mace. The mixture is to be shaken 3 or 4 times daily, coloured with caramel (burnt sugar), filtered at the end of ten days, and set aside in bottles.

Tears of the widow of Malabar, are compounded with the preceding quantity of spirits, sugar, and water, adding 4 drachms of ground cinnamon, 48 grains of cloves, and a like quantity of mace, both in powder. It may be slightly coloured with caramel.

The delight of the Mandarins.—Take spirit, sugar, and water, as above, adding 4 drachms of *anisum China* (*Ging*), as much *ambretta* (seeds of the *hibiscus abelmoschus*, Lin.) all in powder; 2 drachms of safflower.

The sighs of Iova.—Take spirits, water, and sugar, as above. Perfume with essence (otto) of roses; give a very pale pink hue with tincture of cochineal, filter and bottle up.

Crème de macarons.—Add to the spirit, sugar, and water as above, half a pound of bitter almonds, blanched and pounded; cloves, cinnamon, and mace in powder, of each 48 grains. A violet tint is given by the tinctures of tursole and cochineal.

Curacao.—Put into a large bottle nearly full of alcohol of *trente-six* (34° Baumé), the peels of six smooth Portugal oranges, (Seville?) and let them infuse for 15 days; then put into a carboy 10 pounds of spirits of 18° B., 4 pounds of white sugar, and 4 pounds of river water. When the sugar is dissolved, add a sufficient quantity of the orange *zestes* to give flavour, then spice the whole with 48 grains of cinnamon, and as much mace, both in powder. Lastly introduce an ounce of ground Brazil wood, and infuse during 10 days, agitating 3 or 4 times daily. A pretty deep hue ought to be given with caramel.

Swiss extract of wormwood, is compounded as follows:—

Tops of the absinthium majus 4 pounds;

Ditto, absinthium minus 2 pounds;

| | | |
|--|---|-----------------------------------|
| Roots of angelica, Calamus aromaticus, Seeds of the anisum China, Leaves of the dittany of Crete, Alcohol of 20° B., four gallons Imp. | } | of each a few grains at pleasure; |
|--|---|-----------------------------------|

Macerate these substances during eight days, then distil by a gentle fire; draw off two gallons of spirits, and add to it 2 drachms of essential oil of anise-seed. The two gallons left in the still serve for preparing the *vulnery spirituous water*.

Of colouring the *liqueurs*.

Yellow is given with the yellow colouring matter of sunflower (*carthamus*), which is readily extracted by water.

Fawn is given by *caramel*, made by heating ground white sugar in an iron spoon over a charcoal fire, till it assumes the desired tint, and then pouring it into a little cold water.

Red is given by cochineal alone, or with a little alum.

Violet is given by good litmus (turnsole).

Blue and green. — Sulphate of indigo gives the first. After saturating it nearly with chalk, alcohol being digested upon it, becomes blue. This tincture mixed with that of *carthamus* forms a good green.

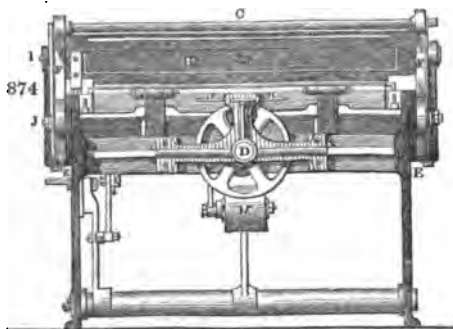
LIQUIDAMBER, is obtained from the *liquidambar styraciflua*, a tree which grows in Mexico, Louisiana, and Virginia. Some specimens are thin, like oil, and others are thickish, like turpentine. It is transparent, amber coloured, has an agreeable and powerful smell, and an aromatic taste, which feels pungent in the throat. Boiling alcohol dissolves it almost entirely. It contains a good deal of benzoic acid, some of which effloresces whenever the liquidamber hardens with keeping.

LITHARGE, (Eng. and Fr.; *Glätte*, Germ.); is the fused yellow protoxide of lead, which on cooling passes into a mass consisting of small six-sided plates, of a reddish yellow colour, and semitransparent. It generally contains more or less red lead, whence the variations of its colour; and carbonic acid, especially when it has been exposed to the air for some time. See **LEAD** and **SILVER**, for its mode of preparation.

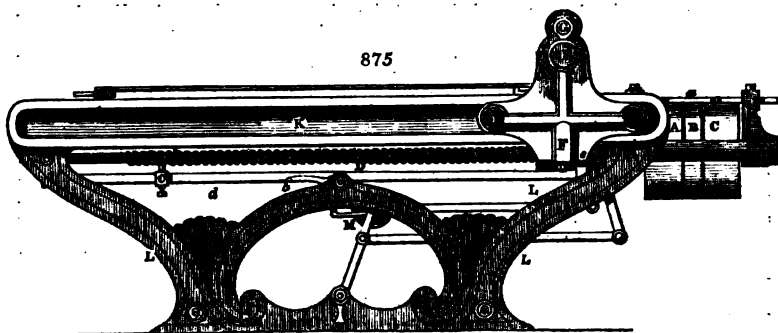
LITHIA, is a simple earthy or alkaline substance, discovered not many years ago in the minerals called petalite and triphane. It is white, very caustic, reddens litmus, and red cabbage, and saturates acids with great facility. When exposed to the air it attracts humidity and carbonic acid. It is more soluble in water than baryta; and has such a strong affinity for it as to be obtained only in the state of a hydrate. It forms neutral salts with all the acids. It is most remarkable for its power of acting upon or corroding platinum.

LITHIUM, is the metallic basis of lithia; the latter substance consists of 100 of metal, and 123 of oxygen.

LITHOGRAPHIC PRESS. The lithographic press in common use has long been regarded as a very inadequate machine. The amount of manual power required to work it, and the slow speed at which, under the most favourable circumstances, copies can be produced, disables lithography in its competition with letter-press. A career of brilliant success has attended the efforts of scientific men towards speed and perfection in this latter branch of the art; and the present printing machines surpass the hand-press somewhat in the same ratio, as does our express speed the jog-trot of our forefathers. The engravings annexed will serve to illustrate Messrs. Napier & Sons'



improvements upon the lithographic press. The machine is arranged to be driven by steam power; has belts, "crossed" and "open," supposed to be in connexion with the engine, and to run upon the pulleys A, B, C. The crank pulley, B, is fixed on the screw-



spindle *n*, and the other two work loose, or "dead," on the same spindle; these bands with their striking forks, *a*, are arranged so as to be brought alternately upon the fixed pulley, *n*, and thus a reversing motion is given to the screw. The nut in which the screw works is fixed to a crosspiece *x*, which braces the side frames *r*, together at bottom, while the bar *g*, performs the same office at top; the scraper-box, *h*, is sustained between these frames at bearings *i*, and is so fitted as to work freely. To support the frames and scraper-box independent of the screw and maintain them in position, allowing freedom of action, the rollers *j*, *j*, are provided, which run in the planed recesses, *x*, along the top of the main standards *l*.

The machine is shown with its tympan down, ready for starting; this is effected by pressing lightly upon the lever, *b*, which raises a catch, and allows the weight *m*, to descend in the direction of its present inclination, and act upon the connections with the striking forks, so as to bring one of the bands upon the fast pulley, *n*, and make the scraper and its frames more forward. The return is caused by the frame, *r*, coming in contact with a stop *c*, which, yielding, acts upon the striking forks by its bar *d*, upon which it may be adjusted to give the travel required. On the return being accomplished the machine stops itself by a striking action against stop, *e*, the catch, *b*, falling in to prevent the weight descending to its full throw, and thus retaining the two bands upon the two dead pulleys, *a* and *c*, while the machine is prepared for another impression.

The action of the scraper is peculiar and novel; it is balanced, so that its tendency is to remain slightly raised, but in its forward movement, and at the point desired, it is made to descend by a stop fixed upon the top of the main standard, *l*, into a position vertical, or nearly so, in which position it is retained by its own onward progress against strong abutments projecting from the frames, *r*; on the return it resumes its raised position and passes back without impediment. The scraper may be adjusted to give the pressure desired, or the table on which the stone is placed regulated by screws.

The advantages embodied in this machine will be at once recognised by those interested. The pulling down of the scraper, and the labour and inconvenience attendant upon that operation, are entirely superseded by the simple and effectual valve-like movement just explained, which forms the ground work of this combination, although it will alike apply to the press work by hand, and is the most striking novelty in the machine.

LITHOGRAPHY. Though this subject belongs rather to the arts of taste and design than to productive manufactures, its chemical principles fall within the province of this Dictionary.

The term *lithography* is derived from *λίθος*, a stone, and *γραφη*, writing, and designates the art of throwing off impressions upon paper, of figures and writing previously traced upon stone. The processes of this art are founded:—

1. Upon the adhesion to a smoothly-polished limestone, of an encaustic fat which forms the lines or traces.
2. Upon the power acquired by the parts penetrated by this encaustic, of attracting to themselves, and becoming covered with a printer's ink, having linseed oil for its basis.
3. Upon the interposition of a film of water, which prevents the adhesion of the ink in all the parts of the surface of the stone not impregnated with the encaustic.
4. Lastly, upon a pressure applied by the stone, such as to transfer to paper the greater part of the ink which covers the greasy tracings of the encaustic.

The lithographic stones of the best quality are still procured from the quarry of Solenhofen, a village at no great distance from Munich, where this mode of printing had its birth. They resemble in their aspect the yellowish white *lias* of Bath, but their geological place is much higher than the *lias*. Abundant quarries of these fine-grained

limestones occur in the county of Pappenheim, along the banks of the Danube, presenting slabs of every required degree of thickness, parted by regular seams, and ready for removal with very little violence. The good quality of a lithographic stone is generally denoted by the following characters; its hue is of a yellowish gray, and uniform throughout; it is free from veins, fibres, and spots; a steel point makes an impression on it with difficulty; and the splinters broken off from it by the hammer display a conchoidal fracture.

The Munich stones are retailed on the spot in slabs or layers of equal thickness, they are quarried with the aid of a saw, so as to sacrifice as little as possible of the irregular edges of the rectangular tables or plates. One of the broad faces is then dressed, and coarsely smoothed. The thickness of these stones is nearly proportional to their other dimensions; and varies from $1\frac{1}{2}$ inches to 3 inches.

In each lithographic establishment, the stones receive their finishing, dressing, and polishing; which are performed like the grinding and polishing of mirror plate. The work is done by hand, by rubbing circularly a moveable slab over another cemented in a horizontal position, with fine sifted sand and water interposed between the two. The style of work that the stone is intended to produce determines the kind of polish that it should get. For crayon drawing the stone should be merely grained more or less *fine* according to the fancy of the draughtsman. The higher the finish of the surface, the softer are the drawings; but the printing process becomes sooner *pasty*, and a smaller number of impressions can be taken. *Works in ink* require the stone to be more softened down, and finally polished with pumice and a little water. The stones thus prepared are packed for use with white paper interposed between their faces.

Lithographic crayons.— Fine lithographic prints cannot be obtained unless the crayons possess every requisite quality. The ingredients composing them ought to be of such a nature as to adhere strongly to the stone, both after the drawing has undergone the preparation of the acid, and during the press-work. They should be hard enough to admit of a fine point, and trace delicate lines without risk of breaking. The following composition has been successfully employed for crayons by MM. Bernard and Delaruc, at Paris:—

| | | | |
|--|---|---|---|
| Pure wax, (first quality) | - | - | 4 |
| Dry white tallow soap | - | - | 2 |
| White tallow | - | - | 2 |
| Gum lac | - | - | 2 |
| Lamp black, enough to give a dark tint | - | - | 1 |
| Occasionally copal varnish | - | - | 1 |

The wax is to be melted over a gentle fire, and the lac broken to bits is then to be added by degrees, stirring all the while with a spatula; the soap is next introduced in fine shavings; and when the mixture of these substances is very intimately accomplished, the copal-varnish, incorporated with the lamp black, is poured in. The heat and agitation are continued till the paste has acquired a suitable consistence; which may be recognised by taking out a little of it, letting it cool on a plate, and trying its quality with a penknife. This composition, on being cut, should afford brittle slices. The boiling may be quickened by setting the rising vapours on fire, which increases the temperature, and renders the exhalations less offensive. When ready, it is to be poured into a brass mould, made of two semi-cylinders joined together by clasps or rings, forming between them a cylindrical tube of the crayon size. The mould should be previously smeathed with a greasy cloth.

M. Lasteurie prescribes a more simple composition, said to be equally fit for the lithographer's use:—

| | | | |
|-------------------------|---|---|---------|
| Dried white tallow soap | - | - | 6 parts |
| White wax | - | - | 6 |
| Lamp black | - | - | 1 |

The soap and tallow are to be put into a small goblet and covered up. When the whole is thoroughly fused by heat, and no clots remain, the black is gradually sprinkled in with careful stirring.

Lithographic ink is prepared nearly on the same principle:—

| | | | | |
|-------------------|---|---|---|-----------|
| Wax | - | - | - | 16 parts. |
| Tallow | - | - | - | 6 |
| Hard tallow soap | - | - | - | 6 |
| Shell-lac | - | - | - | 12 |
| Mastic in tears | - | - | - | 8 |
| Venice turpentine | - | - | - | 1 |
| Lamp black | - | - | - | 4 |

The mastic and lac, previously ground together, are to be heated with care in the turpentine; the wax and tallow are to be added after they are taken off the fire, and when their solution is effected, the soap shavings are to be thrown in. Lastly, the lamp black is to be well intermixed. Whenever the union is accomplished by heat, the operation is finished; the liquor is left to cool a little, then poured out on tables, and, when cold, cut into square rods.

Lithographic ink of good quality ought to be susceptible of forming an emulsion so attenuated, that it may appear to be dissolved when rubbed upon a hard body in distilled or river water. It should be flowing in the pen, not spreading on the stone; capable of forming delicate traces, and very black to show its delineations. The most essential quality of the ink is to sink well into the stone, so as to re-produce the most delicate outlines of the drawing, and to afford a great many impressions. It must therefore be able to resist the acid with which the stone is moistened in the preparation, without letting any of its greasy matter escape.

M. de Lasteirie states that after having tried a great many combinations, he gives the preference to the following:—

| | | | |
|------------------------|---|---|-----------|
| Tallow soap, dried | - | - | 30 parts, |
| Mastic, in tears | - | - | 30 — |
| White soda of commerce | - | - | 30 — |
| Shell-lac | - | - | 150 — |
| Lamp black | - | - | 12 — |

The soap is first put into the goblet and melted over the fire, to which the lac being added fuses immediately; the soda is then introduced, and next the mastic, stirring all the while with a spatula. A brisk fire is applied till all these materials be melted completely, when the whole is poured out into the mould.

The inks now prescribed may be employed equally with the pen and the hair pencil, for writings, black-lead drawings, *aqua tinta*, mixed drawings, those which represent engravings on wood (woodcuts), &c. When the ink is to be used it is to be rubbed down with water, in the manner of China ink, till the shade be of the requisite depth. The temperature of the place ought to be from 84° to 90° Fahr., or the saucer in which the ink-stick is rubbed should be set in a heated plate. No more ink should be dissolved than is to be used at the time, for it rarely keeps in the liquid state for 24 hours; and it should be covered or corked up.

Autographic paper.—Autography, or the operation by which a writing or a drawing is transferred from paper to stone, presents not merely a means of abridging labour, but also that of reverting the writings or drawings into the direction in which they were traced, whilst, if executed directly upon the stone, the impression given by it is inverted. Hence, a writing upon stone must be inverted from right to left to obtain direct impressions. But the art of writing thus is tedious and difficult to acquire, while, by means of the autographic paper and the transfer, proofs are obtained in the same direction with the writing and drawing.

Autographic ink.—It must be fatter and softer than that applied directly to the stone, so that though dry upon the paper, it may still preserve sufficient viscosity to stick to the stone by mere pressure.

To compose this ink, we take —

| | | | |
|-------------------------------|---|---|------------|
| White soap | - | - | 100 parts. |
| White wax of the best quality | - | - | 100 — |
| Mutton suet | - | - | 30 — |
| Shell-lac | - | - | 50 — |
| Mastic | - | - | 50 — |
| Lamp black | - | - | 30 or 35 — |

These materials are to be melted as above described for the lithographic ink.

Lithographic ink and paper.—The following recipes have been much commended:—

| | | | |
|---------------------|---|---|--------------------|
| Virgin or white wax | - | - | 8 parts. |
| White soap | - | - | 2 — |
| Shell-lac | - | - | 2 — |
| Lamp black | - | - | 3 table-spoonsful. |

Preparation.—The wax and soap are to be melted together, and before they become so hot as to take fire, the lamp black is to be well stirred in with a spatula, and then the mixture is to be allowed to burn for 30 seconds; the flame being extinguished, the lac is to be added by degrees, carefully stirring all the time; the vessel is to be put upon the fire once more in order to complete the combination, and till the materials are either kindled or nearly so. After the flame is extinguished, the ink must be suffered to cool a little, and then put into the moulds.

With the ink crayons thus made, lines may be drawn as fine as with the point of the graver, and as full as can be desired, without risk of its spreading in the carriage. Its traces will remain unchanged on paper for years before being transferred.

Some may think it strange that there is no suet in the above composition, but it has been found that ink containing it is only good when used soon after it is made, and when immediately transferred to the stone, while traces drawn on paper with the suet ink become defective after 4 or 5 days.

Lithographic paper. — Lay on the paper, 3 successive coats of sheep-foot jelly,
1 layer of white starch,
1 layer of gamboge.

The first layer is applied with a sponge dipped in the solution of the hot jelly, very equally over the whole surface, but thin; and if the leaf be stretched upon a cord, the gelatine will be more uniform. The next two coats are to be laid on, until each is dry.

The layer of starch is then to be applied with a sponge, and it will also be very thin and equal. The coat of gamboge is lastly to be applied in the same way. When the paper is dry, it must be smoothed by passing it through the lithographic press; and the more polished it is, the better does it take on the ink in fine lines.

Transfer. — When the paper is moistened, the transfer of the ink from the gamboge is perfect and infallible. The starch separates from the gelatine, and if, after taking the paper off the stone, we place it on a white slab of stone, and pour hot water over it, it will resume its primitive state.

The coat of gamboge ought to be laid on the same day it is dissolved, as by keeping it becomes of an oily nature; in this state it does not obstruct the transfer, but it gives a gloss to the paper which renders the drawing or tracing more difficult, especially to persons little habituated to lithography.

The starch paste can be employed only when cold, the day after it is made, and after having the skin removed from its surface.

A leaf of such lithographic paper may be made in two minutes.

In transferring a writing, an ink drawing, or a lithographic crayon, even the impression of a copper-plate, to the stone, it is necessary, 1. that the impressions be made upon a thin and slender body like common paper; 2. that they may be detached and fixed totally on the stone by means of pressure; but as the ink of a drawing sinks to a certain depth in paper, and adheres pretty strongly, it would be difficult to detach all its parts, were there not previously put between the paper and the traces a body capable of being separated from the paper, and of losing its adhesion to it by means of the water with which it is damped. In order to produce this effect, the paper gets a certain preparation, which consists in coating it over with a kind of paste ready to receive every delineation without suffering it to penetrate into the paper. There are different modes of communicating this property to paper. Besides the above, the following may be tried. Take an unsized paper, rather strong, and cover it with a varnish composed of: —

| | | | | |
|------------|---|---|---|-----------|
| Starch | - | - | - | 120 parts |
| Gum arabic | - | - | - | 40 — |
| Alum | - | - | - | 20 — |

A paste of moderate consistence must be made with the starch and some water, with the aid of heat, into which the gum and alum are to be thrown, each previously dissolved in separate vessels. When the whole is well mixed, it is to be applied, still hot, on the leaves of paper, with a flat smooth brush. A tint of yellow colour may be given to the varnish with a decoction of the berries of Avignon, commonly called French berries by our dyers. The paper is to be dried, and smoothed by passing under the scraper of the lithographic press.

Steel pens are employed for writing and drawing with ink on the lithographic stones.

LITMUS (*Turnesol*, Fr.; *Lackmus*, Germ.); is prepared in Holland from the species of lichen called *Lecanora tartarea*, *Rocella tartarea*, by a process which has been kept secret, but which is undoubtedly analogous to that for making archil and cudbear. The ground lichens are first treated with urine containing a little potash, and allowed to ferment, whereby they produce a purple-red; the coloured liquor, treated with quicklime and some more urine, is set again to ferment during two or three weeks, then it is mixed with chalk or gypsum into a paste, which is formed into small cubical pieces, and dried in the shade. Litmus has a violet-blue colour, is easy to pulverize, is partially soluble in water and dilute alcohol, leaving a residuum consisting of carbonate of lime, of clay, silica, gypsum, and oxide of iron combined with the dye. The colour of litmus is not altered by alkalia, but is reddened by acids; and is therefore used in chemistry as a delicate test of acidity, either in the state of solution or of unsized paper stained with it. It is employed to dye marble blue.

LIXIVIATION (*Lessivage*, Fr.; *Auslagen*, Germ.); signifies the abstraction by

water of the soluble alkaline or saline matters present in any earthy admixture; as from that of quicklime and potashes to make potash lye, from that of effloresced alum schist to make aluminous liquors, &c.

LOADSTONE, MAGNETIC IRON-STONE (*Fer oxydulé*, Fr.; *Magnetstein*, Germ.); an iron ore consisting of the protoxide and peroxide of iron in a state of combination.

LOAM (*Terre limoneuse*, Fr.; *Lehm*, Germ.); a native clay mixed with quartz sand and iron ochre, and occasionally with some carbonate of lime.

LOCK (BANK SAFE). The peculiarity of this lock consists in an extension of the key after it is inserted in the lock, and a secret connection between the interior of the key and two of the players. The two inclined planes on the under side of the wards open or shut the extension of the key as it passes over them: the part of the key thus extended operates on two players placed beyond the reach of picklocks, while at the same time the main part of the key works other two players, which are again operated on by the secret apparatus in the interior of the key. This secret apparatus can be removed at pleasure, and the proper key then becomes unfit to work the lock, and skeleton keys, however well fitted to pass the wards, will not operate on the players.

LODE, is the name given by the Cornish miners to a vein, whether it be filled with metallic or earthy matter.

LOGWOOD (*Bois de Campêche*, *Bois bleu*, Fr.; *Blauholz*, Germ.); is the wood of the *Hæmatoxylon Campechianum*, a native tree of central America, grown in Jamaica since 1715. It was first introduced into England in the reign of Elizabeth, but as it afforded to the unskilful dyers of her time a fugitive colour, it was not only prohibited from being used, under severe penalties, but was ordered to be burned wherever found, by a law passed in the 23d year of her reign. The same prejudice existed, and the same law was enacted against indigo. At length, after a century of absurd prohibition, these two most valuable tinctorial matters, by which all our hats, and the greater part of our woollen cloths, are dyed, were allowed to be used.

Old wood, with black bark and with little of the white alburnum, is preferred. Logwood is denser than water, very hard, of a fine compact grain, and almost indestructible by the atmospheric elements; it has a sweet and astringent taste, and a peculiar not inoffensive smell.

For its chemical composition, see **HEMATIN**.

When chipped logwood is for some time exposed to the air, it loses a portion of its dyeing power. Its decoction absorbs the oxygen of the atmosphere, and then acquires the property of precipitating with gelatine, which it had not before. The dry extract of logwood, made from an old decoction, affords only a fugitive colour.

For its applications in dyeing, see **BLACK DYE**; **BROWN DYE**; **CALICO PRINTING**; **DYEING**; **HAT DYEING**, &c.

The imports of logwood were in 1850, 34,690 tons; in 1851, 21,240 tons; of which 3,721 tons and 3,010 tons respectively were re-exported.

LOOM (*Métier à tisser*, Fr.; *Weberstuhl*, Germ.); is the ancient and well-known machine for weaving cloth by the decussation of a series of parallel threads, which run lengthwise, called the warp or chain, with other threads thrown transversely with the shuttle, called the woof or weft. See **JACQUARD LOOM** and **WEAVING**.

LUBRICATION. The following simple and efficacious plan of lubricating the joints and bearings of machinery by capillary attraction, has been kindly communicated to me, by its ingenious inventor, Edward Woolsey, Esq. :—

Fig. 87c. represents a tin cup, which has a small tin tube Δ , which passes through the bottom, as shown by the dotted lines. It may have a tin cover to keep out the dust.

Fig. 877. is a plan of the same.

Fig. 878. is a section of the same. Oil is poured into the cup, the one end of a worsted or cotton thread is dipped into the oil, and the other end passed through the tube. The capillary attraction causes the oil to ascend and pass over the orifice of the tube, whence it gradually descends, and drops slower or quicker, according to the length of the thread or its thickness, until every particle of oil is drawn over by this capillary syphon. The tube is intended to be put into the bearings of shafts, &c., and is made of any size that may be wished. If oil, or other liquids, is desired to be dropped upon a grindstone or other surface, this cup can have a handle to it, or be hung from the ceiling.

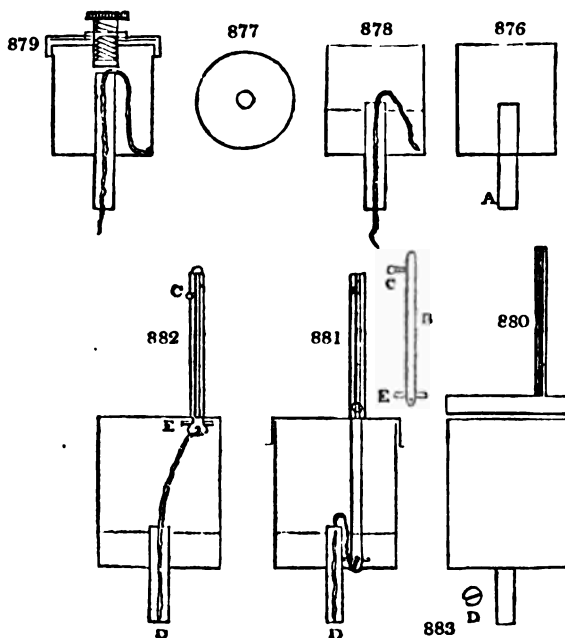
Fig. 879. It is frequently required to stop the capillary action when the machinery is not going; and this has been effected by means of a tightening screw, which passes through a screw boss in the cover of the cup, and presses against the internal orifice of the tube, preventing the oil from passing.

Fig. 880. As I find when these screw cups (*Fig. 879.*) are used upon beams of engines and moving bearings, that the screw is apt to be tightened by the motion; and also, as I think the action of the screw is uncertain, from the workman neglecting to screw it down sufficiently, it answers best to take out the capillary thread when the lubrication

is not required; and to effect this easily, I have a tin top to the cup, with a round pipe soldered to it: this pipe has a slit in it, like a pencil case, and allows a bolt to slide easily in it. In *fig. 881*, the bolt is down; in *fig. 882*, the bolt, which is a piece of brass wire, is drawn up, and there is no capillary action between the thread and the oil. In *fig. 882*, it will be observed, that the bolt is kept in its place by its head *c*, resting in a lateral slit in the pipe, and it cannot be drawn out on account of the pin *x*. One end of the thread is fastened to the eye hole at the bottom of the bolt, and the other end is tied to a small wire which crosses the lower orifice of the tube at *n*, and which is shown in plan *fig. 883*.

By this simple contrivance the capillary action can be stopped or renewed in a second, without removing the top of the lubricator.

The saving by this plan, instead of pouring oil into the bearings, is 2 gallons out of 3, while the bearings are better oiled.



"I send you the drawings of the lubricators, with a detailed explanation. I have omitted to state, that the saving in labour is considerable where there are many joints to keep oiled three or four times a day; and that the workman does not, with this apparatus, run the risk of being caught by the machinery. Perhaps your friends may be at a loss how to tie on the cotton or worsted thread. I pass a long thread through the eye-hole *x* of the bolt, and then draw the two ends through the tube by a fine wire with a hook to it, one end on one side of the cross wire *n*, and the other end on the other side. I then put the cover on, and the bolt in the position shown in *fig. 882*; when by drawing the two ends of the thread, and tying them across the wire *n*, you have the exact length required. When you wish to see the quantity of oil remaining in the lubricator, the bolt must be dropped as in *fig. 881*., and you can then lift the cover a little way off, without breaking the thread, and replenish with oil. The cost of *fig. 881*. in tin plate is 9d. The figures in the wood cuts are one third of the full size.

"Believe me to be yours sincerely,

"E. J. WOOLSET."

LUPININE, is a substance of a gummy appearance, so named by M. Cussola, because it was obtained from Lupines.

LUPULINE, from *Humulus Lupulus*; is the peculiar bitter aromatic principle of the hop. See BEER.

LUTE (from *lutum*, clay; *Lut*, Fr.; *Kitte*, *Beschläge*, Germ.); is a pasty or loamy matter employed to close the joints of chemical apparatus, or to coat their surfaces, and protect them from the direct action of flame. Lutes differ according to the nature of the vapours which they are destined to confine, and the degree of heat which they are to be exposed to.

1. *Lute of linseed meal*, made into a soft plastic dough with water, and immediately applied pretty thick to junctions of glass, or stone-ware, makes them perfectly tight, hardens speedily, resists acid and ammoniacal vapours, as also a moderate degree of heat. It becomes stronger when the meal is kneaded with milk, lime-water, or solution of glue.

2. *Lute of thick gum-water*, kneaded with clay, and iron filings, serve well for permanent junctions, as it becomes extremely solid.

3. By softening in water a piece of thick brown paper, kneading it first with rye-flour paste, and then with some potter's clay, till it acquires the proper consistence, a lute is formed which does not readily crack or scale off.

4. *Lute*, consisting of a strong solution of glue kneaded into a dough with new slaked lime, is a powerful cement, and with the addition of white of egg forms the *lut d'ane*;—a composition adapted to mend broken vessels of porcelain and stone-ware.

5. *Skim-milk cheese*, boiled for some time in water, and then triturated into paste with fresh-slaked lime, forms also a good lute.

6. *Calcined gypsum*, diffused through milk, solution of glue or starch, is a valuable lute, in many cases.

7. A lute made with linseed, melted caoutchouc, and pipe-clay, incorporated into a smooth dough, may be kept long soft when covered in a cellar, and serves admirably to confine acid vapours. As it does not harden, it may therefore be applied and taken off as often as we please.

8. *Caoutchouc* itself, after being melted in a spoon, may be advantageously used for securing joints against chlorine and acid vapours, in emergencies when nothing else would be effectual. It bears the heat at which sulphuric acid boils.

9. The best lute for joining crucibles inverted into each other, is a dough made with a mixture of fresh fire-clay, and ground fire-bricks, worked with water. That cement, if made with solution of borax, answers still better, upon some occasions, as it becomes a compact vitreous mass in the fire. See *CZEMENTA*.

Lute for confining acids. 1 part of caoutchouc dissolved in two parts of hot linseed-oil, and worked up with pipe clay (3 parts) into a plastic mass. Linseed meal and water forms the best lute for fluo-silicic acid.

LUTEOLINE, is a yellow colouring matter discovered by Chevreul in weld. When sublimed, it crystallizes in needles.

LYCOPODIUM CLAVATUM. The seeds of the lycopodium ripen in September. They are employed, on account of their great combustibility, in theatres, to imitate the sudden flash of lightning, by throwing a quantity of them from a powder puff, or bellows, across the flame of a candle.

LYDIAN STONE, is flint-slate.

M.

MACARONI, is a dough of fine wheat flour, made into a tubular or pipe form, of the thickness of goose-quills, which was first prepared in Italy, and introduced into commerce under the name of Italian or Genoese paste. The wheat for this purpose must be ground into a coarse flour, called *grau* or *semoule*, by the French, by means of a pair of light mill-stones, placed at a somewhat greater distance than usual. This *semoule* is the substance employed for making the dough. For the mode of manufacturing it into pipes, see **VERMICELLI**.

MACE, is a somewhat thick, tough, unctuous membrane, reticulated or shapt, of a yellowish-brown or orange colour. It forms the envelope of the shell of the fruit of the *myristica moschata*, which contains the nutmeg. It is dried in the sun, after being dipped in brine; sometimes it is sprinkled over with a little brine, before packing, to prevent the risk of moulding. Mace has a more agreeable flavour than nutmeg; with a warm and pungent taste. It contains two kinds of oil; the one of which is unctuous, bland, and of the consistence of butter; the other is volatile, aromatic, and thinner. The membrane is used as a condiment in cookery, and the aromatic oil in medicine.

The quantity imported in 1850 was 77,337 lbs.; in 1851, 74,863 lbs.; entered for consumption, 1850, 21,997 lbs.; 1851, 21,695 lbs.; duty received, respectively, 2,887*l* and 2,847*l*.

MACERATION (Eng. and Fr.; *Einweichen*, Germ.), is a preparatory step to

which certain vegetable and animal substances are submitted, with the view of distending their fibres or pores, and causing them to be penetrated by such menstrua as are best adapted to extract their soluble parts. Water, alone, or mixed with acids, alkalis, or salts; alcohol and ether, are the liquids usually employed for that purpose.

MACHINES (Self-acting.) *The application of self-acting Machines to the Construction of Machinery.* It is nearly half a century since I first became acquainted with the engineering profession, and at that time the greater part of our mechanical operations were done by hand. On my first entrance into Manchester there were no self-acting tools, and the whole stock of an engineering or machine establishment might be summed up in a few ill-constructed laths, a few drills, and boring machines of rude construction. Now compare any of the present works with what they were in those days, and you will find a revolution of so extraordinary a character, as to appear to those unacquainted with the subject as scarcely entitled to credit. The change thus effected, and the improvements introduced into our constructive machinery, are of the highest importance; and it gives me pleasure to add that they chiefly belong to Manchester, are of Manchester growth, and from Manchester they have had their origin. It may be interesting to know something of the art of tool making, and of the discoveries and progress of machines which have contributed so largely to multiply the manufactures, as well as the construction of other machines employed in practical mechanics. In Manchester the art of calico printing was in its infancy forty years ago; the flat press, and one or at the most two coloured machines, were all that were then in use; the number of those machines is now greatly multiplied, and some of them are capable of printing eight colours at once; and the arts of bleaching, dyeing, and finishing, have undergone equal extension and improvement. In the manufacture of steam-engines there were only three or four establishments that could make them, and those were Bolton and Watt, of Soho; Fenton, Murray and Wood, of Leeds, and Messrs. Sherratts of this town. The engines of that day ranged from 3 to 50 or at the most 70 horses' power; now they are made as high as 500, or in pairs from 1,000 to 1,200 horse. An order for a single engine at that time was considered a great work, and frequently took ten or twelve months to execute; now they are made by dozens, and that with a degree of despatch as to render it no uncommon occurrence to see five or six engines of considerable power leave a single establishment in a month. In machine making the same powers of production are apparent. In this department we find the same activity, the same certainty of action, and greatly increased production in the manufacture of the smaller machines, than can possibly be attained in the larger and heavier description of work. The self-acting turning, planing, grooving, and slotting machines have afforded so much accuracy and facility for construction, as to enable the mechanical practitioner to turn, bore, and shape with a degree of certainty almost amounting to mathematical precision. The mechanical operations of the present day could not have been accomplished at any cost thirty years ago, and what was considered impossible at that time, is now performed with a degree of intelligence and exactitude that never fail to accomplish the end in view, and reduce the most obdurate mass to the required consistency, in all those forms so strikingly exemplified in the workshops of engineers and machinists. To the intelligent and observant stranger who visits these establishments, the first thing that strikes his attention is, the mechanism of the self-acting tools, the ease with which they cut the hardest iron and steel, and the mathematical accuracy with which all the parts of a machine are brought into shape. When these implements are carefully examined, it ceases to be a wonder that our steam-engines and machines are so beautifully and correctly executed. We perceive the most curious and ingenious contrivances adapted to every purpose, and machinery which only requires the attendance of a boy to supply the material and apply the power, which is always at hand. In conclusion, I would observe that it is an honour to this country, that we stand at the head of the engineering and mechanical profession. It is an art—I would call it a science—which has occupied the attention of the greatest men from the days of Galileo and Newton down to those of Watt and Smeaton, and it now receives attentive consideration from some of the ablest and most distinguished men of the present time. And of these I may instance Poncelet, Morni, Humboldt, Brewster, Babbage, Dr. Robinson (of Armagh), Willis and many others, to show the interest that is taken by these great men in the advancement of mechanical science. A great deal has been done, but a great deal more may yet be accomplished, if by suitable instruction we carefully store the minds of our foremen and operatives with useful knowledge, and afford them those opportunities essential to its acquisition. We must try to unite theory with practice, and bring the philosopher into close contact with the practical mechanic. We must try to remove prejudices, and to encourage a sounder system of management in the manufactures, design, and projects of the useful arts. When this is accomplished, we shall no longer witness abortions in construction, but a carefully well-digested system of operations, founded on the unerring laws of physical truth.—*W. Fairbairn, Esq*

MACHINERY FOR CASK MAKING. A novel method of constructing casks, barrels, and all vessels connected with cooperage, may be seen in operation at the Patent Cooperage Works in Wenlock Road, City Road. By the employment of the steam-engine, the circular saw, and a recently-invented jointing and backing machine, a cask of the largest dimensions can be completely formed and made ready for use in the short space of five minutes from the raw material, viz. a piece of oak. The staves of the cask are first cut with straight sides, the circular saw being placed at a right angle with the oak plank. The stave is then placed horizontally, and bent into a curve by a powerful machine, and brought into contact with a circular saw on each side of it, placed at an angle. This process gives the proper shape to the stave, the sides being gradually tapered at the ends, and made to bulge in the middle. The jointing and backing machine, the new invention, is also used for this purpose, and is more rapid in its execution than the angular saws; it in fact works with the most marvellous rapidity and precision. The staves and one end of the cask are then placed in a machine formed of iron rods, called a trussing machine; each rod acts upon a separate stave, and the whole of the staves being equally compressed into a circle, the hoops are placed around them, and the cask is complete. The neatness and finish of the work are equal to what a good cabinet-maker can produce, every part being true and accurate. The calculation is, that 15 workmen, with the use of this machine, can make 150 casks a day; whereas the same number of persons, using only manual labour, could scarcely produce a seventh part of that number. The importance of the invention and the application of steam power to it, may be imagined from the fact that the great brewing firms of the metropolis alone expend many thousand pounds annually in cooperage, that the expenditure of the Navy is still greater, and that the demand of the vintages of the continent is so great that a great deal of wine is lost from the difficulty of furnishing vessels to hold it. The process of this invention will repay the time of a visit to the works.

MACLE, is the name of certain diagonal black spots in minerals, like the ace of diamonds in cards, supposed to proceed from some disturbance of the particles in the act of crystallization.

MADDER (*Garance*, Fr.; *Faberrüthe*, Germ.), a substance very extensively used in dyeing, is the root of the *Rubia tinctorum*, a plant of which two species are distinguished by Linnæus.

The best roots are those which have the size of a writing quill, or, at most, of the little finger. They are semi-transparent, and reddish; have a strong odour, and a smooth bark. They should be of two or three years' growth.

The madder, taken from the ground and picked, must be dried in order to be ground and preserved. In warm climates it is dried in the open air; but elsewhere stoves must be employed.

The stringy filaments and epidermis are to be removed, called *mulle*; as also the pith, so as to leave nothing but the ligneous fibres.

The preparation of madders is carried on in the department of the Rhone, in the following manner.

The roots are dried in a stove, heated by means of a furnace, from which the air is allowed to issue only at intervals, at the moment when it is judged to be saturated with moisture. The furnace-flue occupies a great portion of the floor; above are three close gratings, on which the roots are distributed in layers of about two decimetres (nearly 8 inches). At the end of 24 hours, those which are on the first grated floor directly above the stove are dry, when they are taken away and replaced by those of the superior floors. This operation is repeated whenever the roots over the stove are dry. The dry roots are thrashed with a flail, passed through fanners similar to those employed for corn, and then shaken upon a very coarse sieve. What passes through is further winnowed and sifted through a finer sieve than the first. These operations are repeated five times, proceeding successively to sieves still finer and finer, and setting aside every time what remains on the sieve. What passes through the fifth sieve is rejected as sand and dust. After these operations, the whole fibrous matters remaining on the sieve are cleaned with common fanners, and women separate all the foreign matters which had not been removed before. For dividing the roots, afterwards, into different qualities, a brass sieve is made use of, whose meshes are from six to three millimetres in diameter (from $\frac{1}{4}$ th to $\frac{1}{8}$ th inch E.) What passes through the finest is rejected; and what passes through the coarsest is regarded as of the best quality. These roots, thus separated, are carried into a stove, of a construction somewhat different from the first. They are spread out in layers of about a decimetre in thickness (nearly 4 inches E.), or large lattice-work frames, and the drying is known to be complete, when on taking up a handful and squeezing it, the roots break easily. On quitting the stove, the madder is carried, still hot, into a machine, where it is minced small, and a sieve separates the portion of the bark reduced to powder. This operation is repeated three or four times, and then the boulder is had recourse to. What passes through the sieve,

or the brass meshes of the boulder, is regarded as common madder; and what issues at the extremity of the boulder is called the flour. Lastly, the madder which passes through the boulder is ground in a mill with vertical stones, and then passed through sieves of different sizes. What remains above is always better than what goes through.

The madder of Alsace is reduced to a very fine powder, and its colouring matter is extracted by a much longer ebullition than is necessary for the lizard of the Levant. The prepared madders ought to be carefully preserved from humidity, because they easily imbibe moisture, in which case fermentation spoils their colour.

D'Ambourney and Beckman have asserted, that it is more advantageous to employ the fresh root of madder than what has been submitted to desiccation, especially by means of stoves. But in its state of freshness, its volume becomes troublesome in the dyeing bath, and uniform observation seems to prove that it ameliorates by age. Besides, it must be rendered susceptible of keeping and carrying easily.

It appears that madder may be considered as composed of two colouring substances, one of which is dun (tawny), and the other is red. Both of these substances may combine with the stuff. It is of consequence, however, to fix only the red part. The dun portion appears to be more soluble, but its fixity on stuffs may possibly be increased by the affinity which it has for the red portion.

The different additions made to madder, and the multiplied processes to which it is sometimes exposed, have probably this separation for their chief object.

The red portion of madder is soluble, but in small quantity, in water. Hence but a limited concentration can be given to its solution. If the portion of this substance be too much increased, so far from obtaining a greater effect, we merely augment the proportion of the dun part, which is the more soluble of the two.

In consequence of the Societé Industrielle of Mulhausen having offered in the year 1826 large premiums to the authors of the best analytical investigation of madder, eight memoirs were transmitted to it in the year 1827. They were examined with the greatest care by a committee consisting of able scientific and practical men. None of the competitors, however, fulfilled the conditions of the programme issued by the society; but four of them received a tribute of esteem and gratitude from it; MM. Robiquet and Colin at Paris, Kuhlmann at Lille, and Houton-Libillardière. Fresh premiums were offered for next year, to the amount of 2000 francs.

Every real discovery made concerning this precious root would be of vast consequence to dyers and calico-printers. Both M. Kuhlmann, and Robiquet and Colin, conceived that they had discovered a new principle in madder, to which they gave the name *alizarine*. The latter two chemists treated the powdered madder with sulphuric acid, taking care to let it heat as little as possible. By this action the whole is carbonized, except perhaps the red matter. The charcoal thus obtained is pulverized, mixed with water, thrown upon a filter, and well washed in the cold. It is next dried, ground, and diffused through fifty parts of water, containing six parts of alum. This mixture is then boiled for one quarter of an hour, and thrown upon a filter cloth while boiling hot. The residuum is once more treated with a little warm alum water. The two liquors are to be mixed, and one part of sulphuric acid poured into them; when they are allowed to cool with occasional agitation. Flocks now make their appearance; the clear liquid is decanted, and the grounds are thrown upon a filter. The precipitate is to be washed, first with acidulated water, then with pure water, and dried, when the colouring matter is obtained in a red or purple state. This purple substance, when heated dry, gives out alizarine, and an empyreumatic oil, having an odour of animal matter; while a charcoally matter remains.

M. Dan. Kœchlin, the justly celebrated calico-printer of Mulhausen, has no faith in alizarine as the dyeing principle of madder; and thinks moreover that, were it of value, it could not be extracted on the great scale, on account of the destructive heat which would result from the acid acting upon a considerable body of the ground madder. Their alizarine is not a uniform substance, as it ought to be, if a proximate principle; for samples of it obtained in different repetitions of the process have produced very variable effects in dyeing. The madders of Avignon, though richer in colour than those of Alsace, afford however little or no alizarine. In fact, *purpurine*, the crude substance from which they profess to extract alizarine, is a richer dye than this *pure* substance itself.

Madder contains so beautiful and so fast a colour, that it has become of almost universal employment in dyeing; but that colour is accompanied with so many other substances which mask and degrade it, that it can be brought out and fixed only after a series of operations more or less difficult and precarious. This dye is besides so little soluble, that much of it is thrown away in the dye-house; the portion supposed to be exhausted being often as rich as other fresh madder; hence it would be a most valuable improvement in this elegant art to insulate this tinctorial body, and make it a new product of manufacture.

Before the time of Hausemann, an apothecary at Colmar, the madder bath was subject

to many risks, which that skilful chemist taught dyers how to guard against, by introducing a certain quantity of chalk into the bath. A change of residence led Haussmann to this fortunate result. After having made very fine reds at Rouen, he encountered the greatest obstacles in dyeing the same reds at Logelbach near Colmar, where he went to live. Numerous trials, undertaken with the view of obtaining the same success in his new establishment, proved that the cause of his favourable results at Rouen existed in the water, which contained carbonate of lime in solution, whilst the water of Logelbach was nearly pure. He then tried a factitious calcareous water, by adding chalk to his dye bath. Having obtained the most satisfactory results, he was not long in producing here as beautiful and as solid reds as he had done at Rouen. This practice became soon general among the calico-printers of Alsace, though in many dye-works the chalk is now replaced by lime, potash, or soda. But when the madder of Avignon is used, all these antacid correctives become unnecessary, because it contains a sufficient quantity of carbonate of lime; an important fact first analytically demonstrated by that accurate chemist M. Henri Schlumberger of Mulhausen. Avignon madder indicates the presence of carbonate of lime in it, by effervescing with dilute acids, which Alsace madder does not.

M. Kuhlman found a free acid resembling the malic, in his analysis of madders. But his experiments were confined to those of Alsace. The madders of Avignon are on the contrary alkaline, as may be inferred from the violet tint of the froth of their infusions; whereas that of the Alsace madders is yellowish, and it strongly reddens litmus paper. This important difference between the plants of these two districts depends entirely upon the soil; for madders grown in a calcareous shelly soil in Alsace have been found to be possessed of the properties of the Avignon madder.

The useful action of the carbonate and the phosphate of lime in the madder of Avignon, explains why madders treated with acids which remove their calcareous salts, without taking away their colouring matter, lose the property of forming fast dyes. Many manufacturers are in the habit of mixing together, and with advantage, different sorts of madder. That of Avignon contains so much calcareous matter that, when mixed with the madder of Alsace, it can compensate for its deficiency. Some of the latter is so deficient as to afford colours nearly as fugitive as those of Brazil wood and quercitron. The Alsace madders by the addition of chalk to their baths, become as fit for dyeing Turkey reds as those of Avignon. When the water is very pure, one part of chalk ought to be used to five of Alsace madder, but when the waters are calcareous, the chalk should be omitted. Lime, the neutral phosphate of lime, the carbonate of magnesia, oxide and carbonate of zinc, and several other substances have the property of causing madder to form a fast dye, in like manner as the carbonate of lime.

The temperature of from 50° to 60° R. (145° to 167° F.), is the best adapted to the solution of the colouring matter, and to its combination with the mordants; and thus a boiling heat may be replaced advantageously by the long continuance of a lower temperature. A large excess of the dye-stuff in the bath is unfavourable in two points of view; it causes a waste of colouring matter, and renders the tints dull. It is injurious to allow the bath to cool, and to heat it again.

In a memoir published by the Society of Mulhausen, in September, 1835, some interesting experiments upon the growth of madders in factitious soils are related by M.M. Kœchlin, Persoz, and Schlumberger. A patch of ground was prepared containing from 50 to 80 per cent. of chalky matter, and nearly one fifth of its bulk of good horse-dung. Slips of Alsace and Avignon madders were planted in March, 1834, and a part of the roots were reaped in November following. These roots, though of only six months' growth, produced tolerably fast dyes, nor was any difference observable between the Alsace and the Avignon species; whilst similar slips or cuttings, planted in a natural non-calcareous soil, alongside of the others, yielded roots which gave fugitive dyes. Others were planted in the soil of Palud, transported from Avignon, which contained more than 90 per cent. of carbonate of lime, and they produced roots that gave still faster dyes than the preceding. Three years are requisite to give the full calcareous impregnation to the indigenous madders of Avignon.

As to the function of the chalk, valuable observations, made long ago by M. Daniel Kœchlin, have convinced him, that the combination of two different bases with a colouring matter, gave much more solidity to the dye, in consequence, undoubtedly, of a greater insolubility in the compound. Experiments recently made by him and his colleagues above named prove that in all cases of madder-dyeing under the influence of chalk, a certain quantity of lime becomes added to the aluminous mordant. In the subsequent clearing with a soap bath, some of the alumina is removed, and there remains upon the fibre of the cloth a combination of these two earths in atomic proportions. Thus the chalk is not for the purpose of saturating the acid, as had been supposed, but of forming a definite compound with alumina, and probably also with the fatty bodies, and the colouring matter itself.

The red mordants are prepared commonly in Alsace, as follows:—The crushed alum and acetate of lead being weighed, the former is put into a deep tub, and dissolved by adding a proper quantity of hot water, when about one tenth of its weight of soda crystals is introduced to saturate the excess of acid in the alum. The acetate of lead is now mixed in; and as this salt dissolves very quickly, the reaction takes place almost instantly. Care must be taken to stir for an hour. The vessel should not be covered, lest its contents should cool too slowly.

The different mordants most generally employed for madder are detailed under *Colours, in CALICO-PRINTING and MORDANT*.

Much mordant should not be prepared at once, for sooner or later it will deposit some sub-acetate of alumina. This decomposition takes place even in corked phials in the cold; and the precipitate does not readily dissolve again in acetic acid. All practical men know that certain aluminous mordants are decomposed by heating them, and restored on cooling, as Gay Lussac has pointed out. He observed, that by adding to pure acetate of alumina some alum or sulphate of potash, the mixture acquires the property of forming a precipitate with a heat approaching the boiling point, and of re-dissolving on cooling. The precipitate is alumina nearly pure, according to M. Gay Lussac; but, by M. Kœchlin's more recent researches, it is shown to be sub-sulphate of alumina, containing eight times as much base as the neutral sulphate.

Madder dye.—On account of the feeble solubility of its colouring matter in water, we cannot dye with its decoction; but we must boil the dye-stuff along with the goods to be dyed; whereby the water dissolves fresh portions of the dye, and imparts it in succession to the textile fibres. In dyeing with madder, we must endeavour to fix as little of the dun matter as possible upon the cloth.

Dyeing on wool.—Alumed wool takes, in the madder bath, a red colour, which is not so bright as cochineal red, but it is faster; and as it is far cheaper, it is much used in England to dye soldiers' cloth. A mordant of alum and tartar is employed; the bath of madder, at the rate of from 8 to 16 ounces for the pound of cloth, is heated to such a degree that we can just hold our hand in it, and the goods are then dyed by the wince, without heating the bath more till the colouring matter be fixed. Vitalis prescribes as a mordant, one fourth of alum, and one sixteenth of tartar; and for dyeing, one third of madder, with the addition of a 24th of solution of tin diluted with its weight of water. He raises the temperature in the space of an hour to 200°, and afterwards he boils for 3 or 4 minutes; a circumstance which is believed to contribute to the fixation of the colour. The bath, after dyeing, appears much loaded with yellow matter, because this has less affinity for the alum mordant than the red. Sometimes a little archil is added to the madder, to give the dye a pink tinge; but this is fugitive.

Silk is seldom dyed with madder, because cochineal affords brighter tints.

Dyeing on cotton and linen.—The most brilliant and fastest madder red is the Turkey or Adrianople. The common madder reds are given in the following way:—The yarn or cloth is boiled in a weak alkaline bath, washed, dried and galled, by steeping the cotton in a decoction of bruised galls or of sumach. After drying, it is twice alumed; for which purpose, for every 4 parts of the goods, one part of alum is taken, mixed with 1-16th of its weight of chalk. The goods are dipped into a warm solution of the alum, wrung out, dried, and alumed afresh, with half the quantity. The acetate of alumina mordant, described above, answers much better than common alum for cotton. After the goods are dried and rinsed, they are passed through the dye-bath, which is formed of $\frac{3}{4}$ lb. of good madder for every pound of cotton; and it is raised to the boiling point by degrees, in the space of 50 or 60 minutes. Whenever the ebullition has continued a few minutes, the goods must be removed, washed slightly, and dyed a second time in the same way, with as much madder. They are then washed and passed through a warm soap bath, which removes the dun colouring matter.

Höfnerhoff prescribes for ordinary madder red the following proportions:—20 pounds of cotton yarn; 14 pounds of Dutch madder; 3 pounds of nut-galls; 5 pounds of alum; to which $\frac{1}{2}$ lb. of acetate of lead has been first added, and then a quarter of a pound of chalk.

In the calico-print works the madder goods are passed through a bran bath first, immediately after dyeing; next, after several days' exposure to the air, when the dun dye has become oxidized, and is more easily removed. An addition of chalk, on the principles explained above, is sometimes useful in the madder bath. If bran be added to the madder bath, the colour becomes much lighter, and of an agreeable shade. Sometimes bran water is added to the madder-bath, instead of bran.

Adrianople or Turkey red.—This is the most complicated and tedious operation in the art of dyeing; but it produces the fastest colour which is known. This dye was discovered in India, and remained long a process peculiar to that country. It was afterwards practised in other parts of Asia and in Greece. In 1747, Ferquet and Gnodard brought Greek dyers into France, and mounted near Rouen, and in Lan-

guedoe, Turkey-red dye works. In 1765, the French government, convinced of the importance of this business, caused the processes to be published. In 1808, Reber, at Mariakirch, furnished the finest yarn of this dye, and M. Köchlin became celebrated for his Turkey-red cloth.

Process for Turkey-red. — The first step consists in clearing the yarn or cloth, in alkaline baths, and dipping them in oily liquors, to which sheep's dung was formerly added. This operation is repeated several times, the goods being dried after each immersion. There next follows the cleansing with alkaline liquors to remove the excess of oil, the galling, the aluming, the maddering, the brightening or removing the dun part of the dye by boiling, at a high temperature, with alkaline liquid, and the rosing by boiling in a bath of salt of tin. We shall give some details concerning this tedious manipulation, and the differences which exist in it in the principal dye-works.

At Rouen, where the process was first brought to perfection, two methods are pursued, called the gray and the yellow course or march. In the gray, the dye is given immediately after the cotton has received the oily mordant, the gall, and the alum, as it has then a gray colour. In the yellow course, it is passed through fresh oils, alum, and galls before the maddering, the cotton having then a yellow tint.

Different views have been taken of the principles of the Turkey red dye, and the object and utility of the various steps. The most ancient notion is that of animalizing the cotton by dung and blood, but experience has proved that without any animal matter the finest colour may be obtained. According to Dingler, the cotton is imbued with oil by steeping it in combinations of oil and soda; the oil is altered by repeated dryings at a high temperature; it attracts oxygen from the air, and thereby combines intimately with the cotton fibre, so as to increase the weight of the stuff. The dung, by a kind of fermentation, accelerates the oxidizement, and hence crude oil is preferable to pure. In England, the mucilaginous oils of Gallipoli are preferred, and in Malabar, oils more or less rancid. The drying oils do not answer. The subsequent treatment with the alkaline liquors removes the excess of oil, which has not been oxidized and combined; a hard drying completely changes that which remains in the fibres; the aluming which follows combines alumina with the cotton; the galling tans the fibres, producing a triple compound of oil and alum, which fixes the colouring matter. The object of the other steps is obvious.

According to Wuttich the treatment with oil opens the cotton so as to admit the mordant and the colouring matter, but the oil and soap do not combine with the fibres. In the alkaline baths which follow, the oil is transformed into soap and removed; whence the cotton should not increase in weight in the galling and aluming; the cotton suffers a kind of tanning, and the saline parts of the blood assist in fixing the madder dye.

The German process improved, according to Dingler, consists of the following operations: mordant of an oily soap or a soapy liniment, hard drying; alkaline bath, drying, steeping, rinsing away of the uncombined mordant, drying; galling, drying; aluming, drying, steeping in water containing chalk, rinsing; maddering, airing, rinsing; brightening with an alkaline boil, and afterwards in a bath containing salt of tin; then washing and drying.

The yarn or the cloth must be first well worked in a bath of sheep's dung and oil, compounded as follows: — 25 pounds of sheep's dung are to be bruised in a solution of pure caustic potash of hydrometer strength 3°, and the mixed liquor is to be passed through a sieve. Two pounds of fine oil are now to be poured into 16 pounds of this lye, after which 30 pounds of coarse oil are to be added, with agitation for $\frac{1}{4}$ of an hour. Other 4 pounds of hot lye are to be well stirred in, till the whole is homogeneous. This proportion of mordant is sufficient for 100 pounds of cotton yarn, for 90 pounds of unbleached or 100 pounds of bleached cotton goods. The cotton stuff, after being well wrung out, is to be laid in a chest and covered with a lid loaded with weights, in which state it should remain for five days. At the end of 24 hours, the cotton becomes hot with fermentation, gets imbued with the mordant, and the oil becomes rapidly altered. The goods are next exposed freely to the air during the day, and in the evening they are dried in a hot chamber, exposed to a temperature of 158° F., for 6 or 8 hours, which promotes the oxidizement of the oil.

The goods are now passed the second time through a soapy-oil mordant similar to the first, then dried in the air by day, and in the hot stove by night. The third and fourth oil-soap steeps are given in the same way, but without the dung. The fifth steep is composed of a lye at 2°, after which the goods must also be dried. Indeed from the first to the fourth steep, the cotton stuff should be put each time into a chamber heated to 145° F. for 12 or 15 hours, and during 18 hours after the fifth steep.

The uncombined oil must, in the next place, be withdrawn by the *degraisage*, which consists in steeping the goods for 6 hours in a very weak alkaline lye. After rinsing and wringing, they are dried in the air, and then put into the hot stove.

The goods are now galled in a bath formed of 36 pounds of Sicilian sumach, boiled for 3 hours in 260 pounds of water, and filtered. The residuum is treated with 190 fresh pounds of water. This decoction is heated with 12 pounds of pounded nut-galls to the boiling point, allowed to cool during the night, and used next morning as hot as the hand can bear; the goods being well worked through it. They are again dried in the air, and afterwards placed in a stove moderately heated. They are next passed through a tepid alum bath, containing a little chalk; left afterwards in a heap during the night, dried in the air, and next in the stove. The dry goods are finally passed through hot water containing a little chalk, wrung out, rinsed, and then maddered.

For dyeing, the copper is filled with water, the fire is kindled, and an ounce and a half of chalk is added for every pound of madder; a pound and a quarter of madder being taken for every pound of cotton yarn. The goods are now passed through the bath, so that they penetrate to near its bottom. The fire must be so regulated, that the copper will begin to boil in the course of from $2\frac{1}{2}$ to 3 hours; and the ebullition must be continued for an hour; after which the yarn is aired and rinsed. Cloth should be put into the dye-bath when its temperature is 77° , and winced at a heat of from 100° to 122° during the first hour; at 167° during the second; and at the boiling point when the third hours begins. It is to be kept boiling for half an hour; so that the maddering lasts four hours. Dingler does not add sumach or galls to the madder bath, because their effect is destroyed in the subsequent brightening, and he has no faith in the utility of blood.

After being dyed, the goods are washed, pressed, and subjected to a soapy alkaline bath at a high heat, in a close boiler, by which the dun parts of the galls and the madder are dissolved away, and the red colour remains in all its lustre. This operation is called brightening. It is repeated in a similar liquor, to which some muriate of tin is added for the purpose of enlivening the colour and giving it a rosy tint. Last of all, the goods are rinsed, and dried in the shade.

The *Eiberfeld* process consists for 100 lbs. of the following steps:—

1. Cleaning the cotton by boiling it for 4 hours in a weak alkaline bath, cooling and rinsing.

2. Working it thoroughly four times over in a steep, consisting of 300 pounds of water, 15 pounds of potash, 1 pailful of sheep's dung, and $12\frac{1}{2}$ pounds of olive oil, in which it should remain during the night. Next day it is drained for an hour, wrung out and dried. This treatment with the dung steep, and drying, is repeated 3 times.

3. It is now worked in a bath containing 120 quarts of water, 18 pounds of potash, and 6 quarts of olive oil; then wrung out and dried. This steep is also repeated 4 times.

4. Steeping for a night in the river is the next process: a slight rinsing without wringing, and drying in the air.

5. Bath made of a warm decoction (100° Fahr.) of sumach and nut-galls, in which the goods remain during the night; they are then strongly wrung, and dried in the air.

6. Aluming with addition of potash and chalk; wringing; working it well through this bath, where it is left during the night.

7. Draining, and strong rinsing the following day; piling up in a water cistern.

8. Rinsing repeated next day, and steeping in water to remove any excess of alum from the fibres; the goods continue in the water till they are taken to the dyeing-bath.

9. The maddering is made with the addition of blood, sumach, and nut-galls; the bath is brought to the boil in 1 hour and $\frac{3}{4}$, and kept boiling for half an hour.

10. The yarn is rinsed, dried, boiled from 24 to 36 hours in a covered copper, with an oily alkaline liquid; then rinsed twice, laid for two days in clear water, and dried.

11. Finally, the greatest brightness is obtained by boiling for three or four hours in a soap bath, containing muriate of tin; after which the yarn is rinsed twice over, steeped in water, and dried.

Process of Haussmann.—He treats cotton twice or 4 times in a solution of aluminated potash, mixed with one thirty-eighth part of linseed oil. The solution is made by adding caustic potash to alum. He dries and rinses each time, and dries after the last operation. He then rinses and proceeds to the madder bath. For the rose colour, he takes one pound of madder for one pound of cotton; for carmine red, he takes from 2 to 3 pounds; and for the deepest red, no less than 4 pounds. It is said that the colour thus obtained surpasses Turkey red.

The French process, by Vitalis of Rouen.—First operation. Scouring with a soda lye, of 1° Baumé, to which there is usually added the remainder of the *white* preparation bath, which consists of oil and soda with water. It is then washed, wrung out, and dried.

In the second operation, he states that from 25 to 30 pounds of sheep's dung are commonly used for 100 pounds of cotton yarn. The dung is first steeped for some days

in a lye of soda, of 8° to 10° B. This is afterwards diluted with about 500 pints of a weaker lye, and at the same time bruised with the hand in a copper basin whose bottom is pierced with small holes. The liquor is then poured into a vat containing 5 or 6 pounds of fat oil (Gallipoli), and the whole are well mixed. The cotton is washed in this, and the hanks of yarn are then stretched on perches in the open air, and turned from time to time, so as to make it dry equably. After receiving thus a certain degree of desiccation, it is carried into the drying house, which is heated to 50° Reaumur (144° Fahrenheit), where it loses the remainder of its moisture, which would have prevented it from combining with the other mordants which it is afterwards to receive. What is left of the bath is called *avances*, and is added to the following bath. Two, or even three dung baths are given to the cotton, when it is wished to have very rich colours. When the cotton has received the dung baths, care must be taken not to leave it lying in heaps for any length of time, lest it should take fire; an accident which has occasionally happened.

The white bath is prepared by pouring 6 pounds of fat oil, into 50 pints of soda water, at 1° or sometimes less, according as, by a preliminary trial, the oil requires. This bath ought to be repeated two, three, or even a greater number of times, as more or less body is to be given to the colour.

To what remains of the white bath, and which is also styled *avances*, about 100 pints of soda lye of two or three degrees are added. Through this the cotton is passed as usual. Formerly it was the practice to give two, or three, or even four oils. Now, two are found to be sufficient.

The cotton is steeped for five or six hours in a tepid solution of soda, of 1° at most; it is set to drain, is then sprinkled with water, and at the end of an hour is washed, hank by hank, to purge it entirely from the oil. What remains of the water of degreasing serves for the scouring or first operation.

For 100 pounds of cotton, from 20 to 25 pounds of galls in sorts must be taken, which are bruised and boiled in about 100 pints of water, till they crumble easily between the fingers. The galling may be done at two operations, dividing the above quantity of galls between them, which is thought to give a richer and more uniform colour.

The aluming of 100 pounds of cotton requires from twenty-five to thirty pounds of pure alum, that is, alum entirely free from ferruginous salts. The alum should be dissolved without boiling, in about 100 pints of river or rain water. When the alum is dissolved, there is to be poured in a solution of soda, made with the sixteenth part of the weight of the alum. A second portion of the alkaline solution must not be poured in till the effervescence caused by the first portion has entirely ceased, — and so in succession. The bath of saturated alum, being merely tepid, the cotton is passed through it, as in the gall bath, so as to impregnate it well, and it is dried with the precautions recommended above. The dyers who gall at two times, alum also twice, for like reasons.

For 25 pounds of cotton, 25 pints of blood are prescribed, and 400 pints of water. Whenever the bath begins to warm, 50 pounds of madder are diffused through the bath; though sometimes the madding is given at two operations, by dividing the madder into two portions.

The brightening bath is prepared always for 100 pounds of cotton, with from four to five pounds of rich oil, six pounds of Marseilles white soap, and 600 litres of soda water of 2° B.

The rosing is given with solution of tin, mixed with soap water.

The Turkey-red dye of Messrs. Monteith and Co., of Glasgow, is celebrated all over the world, and merits a brief description here.

The calico is taken as it comes from the loom without bleaching, for the natural colour of the cotton wool harmonizes well with the dye about to be given; it is subjected to a fermentative steep for 24 hours, like that preliminary to bleaching, after which it is washed at the dash wheel. It is then boiled in a lye, containing about 1 pound of soda crystals for 12 pounds of cloth. The oiling process now begins. A bath is made with 10 gallons of Gallipoli oil, 15 gallon measures of sheep's dung not indurated; 40 gallons of solution of soda crystals, of 1.06 specific gravity; 10 gallons of solution of pearl-ash of spec. grav. 1.04; and 140 gallons of water; constituting a milk-white, soapy solution of about spec. grav. 1.022. This liquor is put into a large cylindrical vat, and constantly agitated by the rotation of wooden vanes, which are best constructed on the plan of the mashing apparatus of a brewery, but far slighter. This saponaceous compound is let off as wanted by a stopcock into the trough of a padding machine, in order to imbue every fibre of the cloth in its passage. This impregnation is still more fully ensured by laying the padded cloth aside in wooden troughs during 16 or 18 days. The sheep's dung has been of late years disused by many Turkey-red dyers both in England and France, but it is found to be advantageous in producing the very superior colour of the Glasgow establishment. It is supposed, also, to promote the sub-

sequent bleaching during the exposure on the green, which is the next process in favourable weather, but in bad weather the goods are dried over a hot-fire.

The cloth is padded again with the saponaceous liquor; and again spread on the grass, or dried hard in the stove. This alternation is repeated a third time, and occasionally, even a fourth.

The cloth by this time is varnished as it were with oil, and must be cleansed in a certain degree by being passed through a weak solution of pearl-ash, at the temperature of about 122° Fahr. It is then squeezed by the rollers and dried.

A second system of oiling now commences, with the following liquor:—10 gallons of Gallipoli oil; 30 gallons of soda crystals lye, of spec. grav. 1.06; and 10 gallons of caustic potash lye, of specific gravity 1.04, thoroughly diffused through 170 gallons of water. With this saponaceous liquor the cloth is padded as before, and then passed between squeezing-rollers, which return the superfluous liquor into the padding-trough. The cloth may be now laid on the grass if convenient; but at any rate it must be hard dried in the stove.

These saponifying, grassing, and drying processes, are repeated three times; whereby the cloth becomes once more very oleaginous, and must be cleansed again by steeping in a compound lye of soda crystals and pearl-ash of the spec. grav. 1.012, at the temperature of 122°. The cloth is taken out, squeezed between rollers to save the liquor, and washed. A considerable portion of the mingled alkalis disappear in this operation, as if they entered into combination with the oil in the interior of the cotton filaments. The cloth is now hard dried.

Galling is the next great step in the Turkey-red preparation; and for its success all the oil should have been perfectly saponified.

From 18 to 20 pounds of Aleppo galls (for each 100 lbs. of cloth) are to be bruised and boiled for 3 or 4 hours, in 25 gallons of water, till 5 gallons be evaporated; and the decoction is to be then passed through a sieve. Two pounds of sumach may be substituted for every pound of galls. The goods must be well padded with this decoction, kept at 90° Fahr., passed through squeezing-rollers, and dried. They are then passed through a solution of alum of the sp. gr. 1.04, to which a certain portion of chalk is added to saturate the acid excess of that supersalt; and in this cretaceous mixture, heated to 110°, the cloth is winced and steeped for 12 hours. It is then passed between squeezing-rollers, and dried in the stove.

The *maddering* comes next.

From two to three pounds of madder, ground to powder in a proper mill, are taken for every pound of cloth. The cloth, as usual in maddering, is entered into the cold bath, and winced by the automatic reel during one hour that the bath takes to boil, and during an ebullition of two hours afterwards. One gallon of bullock's blood is added to the cold bath for every 25 pounds of cloth; being the quantity operated upon in one bath. The utility of the blood in improving the colour has been ascribed to its colouring particles; but it is more probably owing to its albuminous matter combining with the margarates of soda and potash condensed in the fibres.

As madder contains a dingy brown colouring matter associated with the fine red, the goods must be subjected to a clearing process to remove the former tinge, which is more fugitive than the latter. Every hundred pounds of cloth are therefore boiled during 12 hours at least, with water containing 5 pounds of soda crystals, 8 pounds of soap, and 16 gallons of the residual pearl-ash and soda-lye of the last cleansing operation. By this powerful means the dun matter is well nigh removed; but it is completely so by a second boil, at a heat of 250° F., in a tight globular copper, along with 5 pounds of soap, and 1 pound of muriate of tin crystals, dissolved in a sufficient body of water for 100 pounds of cloth. The muriate of tin serves to raise the madder red to a scarlet hue. A margarate of tin is probably fixed upon the cloth in this operation.

When the weather permits, the goods should be now laid out for a few days on the grass. Some manufacturers give them a final brightening with a weak bath of a chloride of lime; but it is apt to impoverish the colour.

According to the latest improvements of the French dyers, each of the four processes of oiling, mordanting, dyeing, and brightening differs, in some respects, from the above.

1. Their first step is boiling the cloth for four hours, in water containing one pound of soap for every four pieces. Their saponaceous bath of a creamy aspect is used at a temperature of 75° F.; and it is applied by the padding machine 6 times, with the grassing and drying alternations. In winter, when the goods cannot be exposed on the grass, no less than 12 alternations of the saponaceous or white bath are employed, and 8 in spring. They consider the action of the sun-beam to aid greatly in brightening this dye; but at Midsummer, if it be continued more than 4 hours, the scarlet colour produced begins to be impaired.

They conceive that the oiling operation impregnates the fibres with super-margarate

of potash or soda, insoluble salts which attract and condense the alumina, and the red colouring particles of the madder, so firmly that they can resist the clearing boil.

2. Their second step, the mordanting, consists first in padding the pieces through a decoction of galls mixed with a solution of an equal weight of alum; and after drying in the hot-flue, &c., again padding them in a solution of acetate of alumina, made by decomposing a solution of 16 lbs. of alum with 16 lbs. of acetate of lead, for 6 pieces of cloth, each 32 *aines* long.

3. The maddering is given at two successive operations; with 4 pounds of Avignon madder per piece at each time.

4. The *brightening* is performed by a 12 hours' boil in water with soda crystals, soap, and salt of tin; and the *rosing* by a 10 hours' boil with soap and salt of tin. Occasionally, the goods are passed through a weak solution of chloride of potash. When the red has too much of a crimson cast, the pieces are exposed for two days on the grass, which gives them a bright scarlet tint.

Process of M. Werdet to dye broad cloth and wool by madder: —

“Preparation for 24 pounds of scoured wool:

“Take 4½ pounds of cream of tartar, 4½ pounds of pure alum; boil the wool gently for 2 hours, transfer it into a cool place, and wash it next day in clear water.

“*Dyeing*. — 12 pounds of Avignon madder, infused half an hour at 30° R. (100° F.) Put into the bath 1 pound of muriate of tin, let the colour rise for three quarters of an hour at the same heat, and drain or squeeze the madder through canvas. The whole of the red dye will remain upon the filter, but the water which has passed through will be as deep a yellow as a weld bath. The boiler with the dye must now be filled up with clear river water, and heated to 100° F. Two ounces of the solution of the tartar and alum must be poured into it, and the wool must be turned over in it for an hour and a half, while the heat is gradually raised to the boiling point. The wool is then removed and washed. It must be rosed the following day.

“*Rosing*. — Dissolve in hot water 1 pound of white Marseilles soap; let the bath cool, and pass the wool through it till it has acquired the desired shade; 15 or 20 minutes are sufficient. On coming out of this bath it should be washed.

“*Solution of deuto-muriate of tin*.

“2 ounces of pure muriatic acid; 4 drachms of pure nitric acid; 1 ounce of distilled water. Dissolve in it, by small portions at a time, 2 drachms of grain tin, in a large bottle of white glass, shutting it after putting in the tin. This solution may be preserved for years, without losing its virtue.”

I have inserted this process, as recently recommended by the French minister of commerce, and published by M. Pouillet in vol. i. of his *Portefeuille Industriel*, to show what *official* importance is sometimes given by our neighbours to the most frivolous things.

MADREPORES, are calcareous incrustations produced by *polypi* contained in cells of greater or less depth, placed at the surface of calcareous ramifications, which are fixed at their base, and perforated with a great many pores. The mode of the increase, reproduction, and death of these animals is still unknown to naturalists. Living madrepores are now-a-days to be observed only in the South American, the Indian, and the Red seas; but although their *polypi* are not found in our climate at present, there can be no doubt of their having existed in these northern latitudes in former times, since fossil madrepores occur in both the older and newer secondary strata of Europe.

MAGISTERY, is an old chemical term to designate white pulverulent substances, spontaneously precipitated in making certain metallic solutions; as magistry of bismuth.

MAGISTRAL, in the language of the Spanish smelters of Mexico and South America, is the roasted and pulverized copper pyrites, which is added to the ground ores of silver in their *patio*, or amalgamation magma, for the purpose of decomposing the horn silver present. See SILVER, for an account of this curious process of reduction.

MAGMA, is the generic name of any crude mixture of mineral or organic matters, in a thin pasty state.

MAGNANIER, is the name given in the southern departments of France to the proprietor of a nursery in which silk-worms are reared upon the great scale, or to the manager of the establishment. The word is derived from *magnans*, which signifies silk-worms in the language of the country people. See SILK.

MAGNESIA (Eng. and Fr.; *Bittererde*, *Talkerde*, Germ.), is one of the primitive earths, first proved by Sir H. Davy to be the oxide of a metal, which he called *magnesium*. It is a fine, light, white powder, without taste or smell, which requires 51.50 parts of cold water, and no less than 36,000 parts of boiling water, for its solution. Its specific gravity is 2.3. It is fusible only by the heat of the hydroxygen blowpipe. A natural hydrate is said to exist which contains 30 per cent. of water. Magnesia changes

the purple infusion of red cabbage to a bright green. It attracts carbonic acid from the air, but much more slowly than quicklime. It consists of 61.21 parts of metallic basis, and 38.79 of oxygen; and has, therefore, 20 for its prime equivalent upon the hydrogen scale. Its only employment in the arts is for the purification of fine oil, in the preparation of varnish.

Magnesia may be obtained by precipitation with potash or soda, from its sulphate, commonly called Epsom salt; but it is usually procured by calcining the artificial or natural carbonate. The former is, properly speaking, a subcarbonate, consisting of 44.69 magnesia, 35.86 carbonic acid, and 19.45 water. It is prepared by adding to the solution of the sulphate, or the muriate (the *bitters* of sea-salt evaporation works), a solution of carbonate of soda, or of carbonate of ammonia distilled from bones in iron cylinders. The sulphate of magnesia is generally made by acting upon magnesian limestone with somewhat dilute sulphuric acid. The sulphate of lime precipitates, while the sulphate of magnesia remains in solution, and may be made to crystallize in quadrangular prisms, by suitable evaporation and slow cooling. Where muriatic acid may be had in profusion for the trouble of collecting it, as in the soda works in which sea salt is decomposed by sulphuric acid, the magnesian limestone should be first acted upon with as much of the former acid as will dissolve out the lime, and then, the residuum being treated with the latter acid, will afford a sulphate at the cheapest possible rate; from which magnesia and all its other preparations may be readily made. Or, if the equivalent quantity of calcined magnesian limestone be boiled for some time in bitter, the lime of the former will displace the magnesia from the muriatic acid of the latter. This is the most economical process for manufacturing magnesia. The subcarbonate, or *magnesia alba* of the apothecary, has been proposed by Mr. E. Davy to be added by the baker to damaged flour, to counteract its aescency.

MAGNESIAN LIMESTONE (*Dolomie*, Fr.; *Bittertalk*, *Talkspath*, Germ.), is a mineral which crystallizes in the rhombohedral system. Spec. grav. 2.86; scratches calc-spar; does not fall spontaneously into powder, when calcined, as common limestone does. It consists of 1 prime equivalent of carbonate of lime = 50, associated with 1 of carbonate of magnesia = 42.

Massive magnesian limestone, is yellowish-brown, cream-yellow, and yellowish-gray; brittle. It dissolves slowly and with feeble effervescence in dilute muriatic acid; whence it is called *Calcaire lent dolomie* by the French mineralogists. Specific gravity 2.6 to 2.7.

Near Sunderland, it is found in flexible slabs. The principal range of hills composing this geological formation in England, extends from Sunderland on the north-east coast to Nottingham, and its beds are described as being about 300 feet thick on the east of the coal field in Derbyshire, which is near its southern extremity. On the western side of the Cumberland mountains magnesian limestone overlies the coal measures near Whitehaven. The stratification of this rock is very distinct, the individual courses of stone not exceeding in general the thickness of a common brick.

The lime resulting from the calcination of magnesian limestone appears to have an injurious action on vegetation, unless applied in quantities considerably less than common lime, when it is found to fertilize the soil. After two years, its hurtful influence on the ground seems to become exhausted, even when used in undue quantity: great quantities of it are annually brought from Sunderland to Scotland by the Fifeshire farmers, and employed beneficially by them as a manure, in preference to other kinds of lime. It has been unfairly denounced by Mr. Tennant and Sir H. Davy, as a sterilizer.

This rock is used in many places for building; indeed our most splendid monument of Gothic architecture, York Minster, is constructed of magnesian limestone.

MAGNESIA, NATIVE (*Brucite*; *Guhr magnesian*, Fr.; *Wassertalk*, Germ.), is a white, lamellar, pearly-looking mineral, soft to the touch. Spec. grav. 2.336; tender; scratched by calc-spar; affording water by calcination; leaving a white substance which browns turmeric paper; and, by calcination with nitrate of cobalt, becoming of a lilac hue. It consists of 69.75 magnesia, and 30.25 water. It occurs in veins in the serpentine at Hoboken, in New Jersey, as also, at Swinans, in the Island of Unst, Shetland.

MAGNESITE, *Giobertite*; native carbonate of magnesia, occurs in white, hard, stony masses, in the presidency of Madras, and in a few other localities. It dissolves very slowly in muriatic acid, and gives out carbonic acid in the proportion of 22 parts by weight to 42 of the mineral, according to my experiments, and is therefore an atomic carbonate. It forms an excellent and beautiful mortar cement for terraces; a purpose to which it has been beneficially applied in India by Dr. Macleod.

MAGNET, NATIVE, is a mineral consisting of the protoxide and peroxide of iron combined in equivalent proportions. See IRON.

MAHALEB. The fruit of this shrub affords a violet dye, as well as a fermented liquor like *Kirschwasser*. It is a species of cherry cultivated in our gardens.

MALACHITE, or *mountain green*, is native carbonate of copper of a beautiful green colour, with variegated radiations and zones; spec. grav. 3.5; it scratches calc-spar, but not fluor; by calcination it affords water and turns black. Its solution in the acids deposits copper upon a plate of iron plunged into it. It consists of carbonic acid 18.5; deutoxide of copper 72.2; water 9.3.

MALATES, are saline compounds of the bases, with

MALIC ACID. (*Acide malique*, Fr.; *Apfelsaure*, Germ.) This acid exists in the juices of many fruits and plants, alone or associated with the citric, tartaric, and oxalic acids; and occasionally combined with potash or lime. Unripe apples, sloes, barberries, the berries of the mountain ash, elder berries, currants, gooseberries, strawberries, raspberries, bilberries, brambleberries, whottleberries, cherries, ananas, afford malic acid; the house leek and purslane contain the malate of lime.

The acid may be obtained most conveniently from the juice of the berries of the mountain ash, or barberries. This must be clarified, by mixing with white of egg, and heating the mixture to ebullition; then filtering, digesting the clear liquor with carbonate of lead, till it becomes neutral; and evaporating the saline solution, till crystals of malate of lead be obtained. These are to be washed with cold water, and purified by re-crystallization. On dissolving the white salt in water, and passing a stream of sulphuretted hydrogen through the solution, the lead will be all separated in the form of a sulphuret, and the liquor, after filtration and evaporation, will yield yellow granular crystals, or cauliflower concretions, of malic acid, which may be blanched by re-dissolution and digestion with bone-black, and re-crystallization.

Malic acid has no smell, but a very sour taste, deliquesces by absorption of moisture from the air, is soluble in alcohol, fuses at 150° Fahr., is decomposed at a heat of 348°, and affords by distillation a peculiar acid, the pyromalic. It consists in 100 parts, of 41.47 carbon; 3.51 hydrogen; and 55.02 oxygen; having nearly the same composition as citric acid. A crude malic acid might be economically extracted from the fruit of the mountain ash, applicable to many purposes; but it has not hitherto been manufactured upon the great scale.

MALLEABILITY, is the property belonging to certain metals, of being extended under the hammer. A table of malleability is given in the article **DUCTILITY**.

MALT; (Eng. and Fr.; *Malz*, Germ.) is barley-corn, which has been subjected to an artificial process of germination. See **BEER**.

The Quantity of Malt consumed by the undermentioned Brewers of London and its Vicinity, from 10th October, 1830, to 10th October, 1842.

| Name. | 1831. | 1832. | 1833. | 1834. | 1835. | 1836. | 1837. | 1838. | 1839. | 1840. | 1841. | 1842. |
|-----------------------|--------|--------|--------|--------|---------|---------|---------|---------|--------|---------|--------|---------|
| | Qrs. | Qrs. | Qrs. | Qrs. | Qrs. | Qrs. | Qrs. | Qrs. | Qrs. | Qrs. | Qrs. | Qrs. |
| Barclay and Co. - | 97,198 | 96,512 | 93,175 | 99,574 | 106,096 | 114,715 | 100,326 | 107,455 | 90,140 | 115,561 | 98,345 | 114,090 |
| Hanbury and Co. - | 50,724 | 58,512 | 58,497 | 74,982 | 78,087 | 89,303 | 81,440 | 91,029 | 91,029 | 88,210 | 98,132 | 92,456 |
| Whitbread and Co. - | 49,713 | 53,941 | 50,067 | 49,105 | 55,209 | 53,694 | 47,012 | 45,460 | 51,979 | 53,622 | 51,427 | 52,098 |
| Reid and Co. - | 43,390 | 44,420 | 40,810 | 44,210 | 49,430 | 49,381 | 42,700 | 44,928 | 44,010 | 48,130 | 47,980 | 50,120 |
| Meux and Co. - | 24,339 | 22,062 | 20,711 | 26,161 | 24,376 | 30,775 | 30,623 | 35,065 | 38,466 | 40,787 | 49,797 | 43,340 |
| Combe and Co. - | 34,684 | 36,948 | 36,070 | 35,438 | 36,922 | 42,169 | 40,454 | 43,444 | 40,712 | 34,368 | 36,460 | 40,484 |
| Calvert and Co. - | 30,525 | 32,812 | 31,433 | 31,460 | 32,263 | 30,859 | 32,325 | 31,529 | 31,028 | 30,872 | 30,614 | 30,660 |
| Hoare and Co. - | 24,102 | 26,821 | 25,407 | 29,796 | 31,545 | 32,623 | 32,347 | 31,274 | 31,008 | 30,310 | 29,490 | 29,607 |
| Elliot and Co. - | 19,444 | 20,061 | 19,809 | 25,009 | 28,728 | 26,338 | 24,150 | 22,486 | 22,990 | 25,367 | 25,379 | 27,050 |
| Thorne, T. and Son | 1,445 | 2,543 | 5,136 | 8,496 | 10,913 | 12,657 | 16,404 | 18,545 | 19,578 | 20,864 | 22,413 | 22,022 |
| Charrington and Co. | 10,531 | 9,648 | 15,617 | 18,157 | 19,213 | 19,445 | 18,842 | 20,290 | 18,698 | 18,398 | 17,840 | 20,423 |
| Seward and Co. | 8,116 | 6,872 | - | - | - | - | - | - | - | - | - | - |
| Taylor and Co. - | 21,845 | 21,735 | 21,115 | 20,835 | 22,885 | 24,971 | 23,556 | 27,320 | 25,955 | 27,300 | 21,424 | 19,430 |
| Godings, J. and Co. | 16,207 | 14,874 | 14,379 | 15,255 | 16,312 | 14,023 | 14,028 | 12,145 | 12,145 | - | - | - |
| Godings, Thomas | 9,987 | 8,971 | 7,630 | 8,824 | 7,618 | 7,025 | 7,551 | 5,759 | 5,759 | 18,517 | 16,018 | 17,071 |
| Ramsbottom and Co. | - | - | - | - | - | 15,364 | 15,227 | 13,012 | - | - | - | - |
| Broadwood and Co. | - | - | - | - | - | - | - | - | 10,610 | 14,630 | 15,791 | 16,688 |
| Gardner, H. W. and P. | 6,666 | 5,904 | 7,471 | 11,429 | 14,699 | 15,266 | 16,921 | 17,594 | 15,559 | 13,126 | 14,546 | - |
| Mann, James - | - | 1,066 | 1,332 | 1,777 | 2,780 | 4,840 | 6,588 | 10,286 | 11,829 | 11,679 | 12,111 | 13,339 |
| Courage and Co. - | 8,116 | 7,507 | 7,546 | 8,079 | 8,790 | 9,239 | 9,286 | 10,723 | 10,556 | 11,532 | 12,398 | 13,016 |
| Wood and Co. - | 5,469 | 5,560 | 5,647 | 7,602 | 7,320 | 7,961 | 7,834 | 8,506 | 7,667 | 7,194 | 7,268 | 7,652 |
| More, Robert - | 2,535 | 1,040 | 1,890 | 4,713 | 4,130 | 5,255 | 6,025 | 6,129 | 6,413 | 6,954 | 7,175 | 7,026 |
| Harris, Thomas - | 4,778 | 4,780 | 4,540 | 4,940 | 4,964 | 4,998 | 5,042 | 5,888 | 5,296 | 5,152 | 5,291 | 6,022 |
| Hazard and Co. - | - | 6,126 | 6,203 | 7,094 | - | 6,507 | 6,674 | 6,552 | 6,259 | 6,729 | 6,598 | 6,598 |
| Fubb, William - | - | - | - | 80 | 200 | 1,516 | 2,826 | 3,265 | 4,060 | 4,478 | 4,944 | 5,503 |
| Richmond and Co. | 3,783 | 3,808 | 3,956 | 3,820 | 3,368 | 3,551 | 3,174 | 4,058 | 4,536 | 4,964 | 5,030 | 5,434 |
| Hodgson and Co. | 4,206 | 3,322 | 3,870 | 2,060 | 2,414 | 3,400 | 2,400 | 1,790 | 5,358 | 5,704 | 5,862 | - |
| Abbott, E. - | - | - | - | - | - | - | - | - | - | - | - | 4,983 |
| Manners and Co. | - | - | - | - | - | - | - | 4,582 | 6,121 | 7,030 | 5,334 | 4,821 |
| Hale, George - | 4,584 | 4,222 | 3,633 | 3,281 | 3,466 | 3,768 | 4,547 | 5,030 | 4,816 | 4,443 | 4,418 | 4,468 |
| Halford and Co. - | 3,215 | 3,187 | 3,330 | 3,543 | - | 3,763 | 3,786 | 4,656 | 3,967 | 3,585 | - | - |
| Kempson and Co. | - | - | - | - | - | - | - | - | - | - | 3,155 | 3,878 |
| Farren and Till - | - | 3,139 | 3,217 | - | - | 4,048 | 4,783 | 4,599 | 4,400 | 4,426 | - | - |
| Thorne, J. M. and Son | - | - | - | - | - | - | - | - | - | - | 3,860 | 3,676 |
| Duggan and Co. - | - | - | - | - | - | 2,201 | 2,665 | 2,288 | 3,020 | 3,001 | 2,574 | - |
| Jaskell and Downs | - | - | - | - | - | - | - | - | - | - | - | 3,354 |

| Name. | 1831. | 1832. | 1833. | 1834. | 1835. | 1836. | 1837. | 1838. | 1839. | 1840. | 1841. | 1842. |
|-----------------------|------------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|------------|
| Mc.Leod, B. | Qrs. 1,656 | 2,947 | 4,236 | 5,479 | 5,360 | 4,689 | 4,960 | 4,700 | 4,300 | 3,410 | 3,305 | Qrs. 3,222 |
| Pitimmer | - | - | - | - | - | - | - | - | - | 788 | 1,653 | 3,222 |
| Laxton and Bryan | 4,048 | 3,020 | 2,941 | 3,506 | 4,187 | 3,573 | 3,563 | 3,167 | 3,213 | 2,658 | 2,579 | 2,727 |
| Draper and Co. | - | - | - | - | - | - | - | - | 1,658 | 1,711 | 1,787 | 2,727 |
| Miller and Co. | - | - | - | - | - | - | - | - | 855 | 1,167 | 1,740 | 2,447 |
| Keene and Co. | - | - | - | - | - | - | - | - | 3,326 | 2,345 | 2,645 | 2,447 |
| Lane and Bowden | - | - | - | - | - | - | 88 | 393 | 1,275 | 1,964 | 2,010 | 2,429 |
| Fleming and Co. | - | - | - | - | - | - | - | 1,787 | 1,795 | 2,159 | 2,417 | 2,377 |
| Clarke, Charles | 814 | 857 | 1,006 | 1,003 | 1,006 | 1,009 | 1,330 | 1,624 | 1,848 | 1,984 | 2,124 | 2,377 |
| Gurney, J. and Co | - | - | - | - | - | - | - | 614 | 1,903 | 2,357 | 2,217 | 2,377 |
| Stains and Fox | 2,235 | 1,832 | 2,163 | 2,266 | 3,106 | 3,738 | 3,783 | 3,749 | 3,073 | 3,406 | 3,526 | 3,526 |
| Verrey, W. and G. | - | - | 844 | 1,140 | 1,208 | 1,302 | 1,573 | 1,735 | 1,749 | 1,762 | 1,825 | 1,847 |
| Jones, T. | 585 | 468 | 337 | 375 | 248 | 700 | 936 | 1,338 | 1,555 | 1,679 | 1,810 | 1,847 |
| Herington and Wells | - | - | - | - | - | - | - | - | 1,538 | 1,905 | 1,746 | 1,847 |
| Hill and Rice | 2,910 | 1,748 | 1,974 | 1,963 | 2,042 | 1,873 | 1,853 | 1,911 | 1,835 | 1,677 | 1,697 | 1,697 |
| Holt and Sons | 1,113 | 754 | 717 | 794 | 734 | 813 | 756 | 846 | 607 | 1,093 | 972 | 1,093 |
| Cox, John | 2,302 | 2,279 | 4,271 | 2,446 | 2,499 | 2,018 | 2,151 | 1,991 | 1,861 | 1,723 | 1,529 | 1,529 |
| Griffith, P. | 2,146 | 1,530 | 1,063 | 1,693 | 2,120 | 2,284 | 2,221 | 1,884 | 1,553 | 1,916 | 1,119 | 1,429 |
| Uford and Co. | - | - | - | 203 | 472 | 731 | 953 | 1,291 | 1,241 | 1,301 | 1,350 | 1,350 |
| Masterman and Co. | 1,704 | 1,803 | 1,830 | 1,810 | 1,877 | 1,789 | 1,914 | 1,847 | 1,789 | 1,672 | 1,892 | 1,892 |
| Johnson and Co. | - | - | - | - | - | 2,809 | 2,809 | 2,428 | 2,412 | 2,413 | 2,304 | 2,304 |
| Wyatt | - | - | - | - | - | - | - | - | - | - | - | 1,257 |
| Turner, R. | 98 | 198 | 218 | 241 | 531 | 716 | 719 | 897 | 1,013 | 1,077 | 1,219 | 1,219 |
| Dickenson, G. | 901 | 719 | 801 | 793 | 838 | 1,037 | 1,025 | 1,010 | 1,080 | 1,100 | 1,092 | 1,100 |
| Honeyball, Edward | - | - | 269 | 471 | 800 | 1,103 | 1,512 | 1,714 | 1,409 | 1,155 | 1,053 | 1,053 |
| Jenner, R. and H. | - | 209 | 355 | 529 | 734 | 773 | 833 | 925 | 856 | 929 | 955 | 1,077 |
| Church, J. L. | - | - | - | - | - | 756 | 742 | 672 | 975 | 949 | 1,049 | 1,049 |
| Blugg, B. | 603 | 684 | 594 | 753 | 968 | 1,067 | 943 | 1,006 | 1,143 | 1,034 | 1,113 | 1,143 |
| M'Leod, J. M. and Co. | - | - | - | - | - | 748 | 820 | 978 | 877 | 782 | 797 | 1,025 |
| Satchell and Son | 2,508 | 3,117 | 1,906 | 2,515 | 2,147 | 2,177 | 1,441 | 1,431 | 1,475 | 1,306 | 1,062 | 947 |
| Knight | - | - | - | - | - | - | - | - | - | 78 | 883 | 847 |
| Chadwick, W. | - | - | - | - | - | - | 169 | 361 | 532 | 775 | 820 | 847 |
| Turner, John | 674 | 544 | 640 | 677 | 709 | 786 | 766 | 821 | 853 | 728 | 768 | 768 |
| Locke, H. | - | 95 | 329 | 422 | 496 | 620 | 651 | 725 | 760 | 776 | 765 | 737 |
| Hume, George | 1,018 | 985 | 975 | 1,427 | 1,256 | 1,283 | 1,136 | 1,160 | 812 | 719 | 718 | 708 |
| Collins, W. L. | 205 | 176 | 254 | 441 | 519 | 527 | 558 | 407 | 363 | 620 | 627 | 708 |
| West, J. H. | 846 | 877 | 904 | 352 | 406 | 406 | 565 | 749 | 584 | 627 | 708 | 708 |
| Mantell and Son | 1,187 | 840 | 914 | 850 | 757 | 807 | 693 | 650 | 694 | 723 | 641 | 641 |
| Addison | 756 | 590 | 596 | 653 | 671 | 619 | 768 | 812 | 637 | 73 | 638 | 642 |
| Martin and Co. | - | - | - | - | - | - | 397 | 501 | 849 | 592 | - | - |
| Allan | - | - | - | - | - | - | - | - | - | - | 637 | 640 |
| Hood and Co. | - | - | 271 | 488 | 671 | 839 | 649 | 531 | 504 | 594 | 644 | 644 |
| Clarke, W. | - | - | - | - | - | - | - | - | - | 462 | 506 | 525 |
| Clarke, S. | 722 | 841 | 876 | 938 | 793 | 837 | 741 | 768 | 547 | 430 | 502 | 529 |
| Bye, W. and H. | - | - | - | - | - | - | 201 | 260 | 346 | 433 | 489 | 510 |
| Clarke | 545 | 719 | 780 | 747 | 706 | 853 | 834 | 983 | - | - | - | - |
| Rudge | - | - | - | - | - | - | - | - | 896 | 555 | 449 | 501 |
| Bricheno, Henry | 5,637 | 5,732 | 7,120 | 9,950 | 9,762 | 9,885 | 9,863 | 8,857 | 8,699 | - | - | - |
| Lamont and Co. | 1,646 | 356 | 883 | 657 | 403 | 2,085 | 2,600 | 5,251 | 7,638 | 13,475 | 13,067 | - |
| Filmer and Gooding | - | - | - | - | - | 1,039 | 1,298 | 1,291 | 1,674 | 1,633 | 1,514 | - |
| Wood and Co. | - | - | - | - | - | - | - | - | 1,419 | 1,419 | 1,484 | - |
| Brown, late Hicks | - | - | - | - | - | - | - | - | 1,351 | 1,450 | 1,300 | - |
| Manvell, Isaac | 752 | 713 | 924 | 875 | 834 | 805 | 824 | 756 | 579 | 732 | 770 | - |
| Abbott, E. | 691 | - | 525 | 634 | 654 | 2,305 | 560 | 441 | 312 | 487 | 490 | - |
| Cooper, W. | 244 | - | 443 | - | 199 | 310 | 315 | 370 | 434 | 503 | 485 | - |
| Saunders | - | - | - | - | - | - | - | 81 | 311 | 362 | 471 | - |
| West, J. W. | - | - | 179 | 225 | 406 | 205 | 306 | 251 | 290 | 353 | 444 | - |
| Harris, Robert | - | - | 451 | 490 | 557 | 497 | 870 | 456 | 405 | 447 | 441 | - |

Quantity of Malt which paid Duty, and Amount of Duty, in the Years 1842 to 1845.

| | Quantity. | | | | Amount of Duty. | | | |
|----------|---------------------|-----------|-----------|-----------|-----------------|-----------|-----------|-----------|
| | 1842. | 1843. | 1844. | 1845. | 1842. | 1843. | 1844. | 1845. |
| England | Quarters. 3,554,850 | 3,850,567 | 3,979,020 | 3,925,871 | 3,959,420 | 4,171,447 | 4,310,605 | 4,233,027 |
| Scotland | 484,778 | 446,220 | 478,562 | 543,586 | 525,176 | 483,406 | 518,442 | 584,895 |
| Ireland | 130,297 | 162,886 | 169,665 | 218,020 | 141,155 | 176,459 | 172,970 | 236,196 |
| Total | 4,269,925 | 4,459,673 | 4,617,247 | 4,687,477 | 4,625,751 | 4,831,311 | 5,002,017 | 5,078,118 |

Quantity of Malt wetted in Public Brewing in the United Kingdom in the undermentioned Years.

| | | | | | | | |
|------|---|---|---------------------|------------------|---|---|---------------------|
| 1837 | - | - | Quarters. 4,030,534 | 1843 | - | - | Quarters. 2,565,300 |
| 1838 | - | - | 4,040,395 | 1844 | - | - | 3,701,307 |
| 1839 | - | - | 4,082,368 | 1845 | - | - | 2,749,124 |
| 1840 | - | - | 3,985,273 | 1850 | - | - | 5,183,617 |
| 1841 | - | - | 3,678,013 | 1851 (10 months) | - | - | 4,853,118 |
| 1842 | - | - | 3,388,477 | | | | |

An Account of the Quantities of Malt brewed by the Twelve principal London Porter and Ale Brewers, during the 5 Years ending with October 1842 (from Slater's Brewers' Malt List).

| | 1838. | 1839. | 1840. | 1841. | 1842. |
|-----------------------|---------|---------|---------|---------|---------|
| | Qrs. | Qrs. | Qrs. | Qrs. | Qrs. |
| Barclay & Co. - - - | 107,455 | 112,276 | 115,561 | 106,345 | 114,090 |
| Hanbury & Co. - - - | 90,140 | 91,069 | 98,210 | 88,132 | 92,469 |
| Whitbread & Co. - - - | 45,460 | 51,979 | 53,622 | 51,457 | 52,098 |
| *Reid & Co. - - - - | 44,928 | 44,010 | 48,130 | 47,980 | 50,120 |
| *Meux & Co. - - - - | 35,065 | 38,465 | 40,787 | 39,797 | 40,340 |
| Combe & Co. - - - - | 43,444 | 40,712 | 38,368 | 36,460 | 46,484 |
| Calvert & Co. - - - - | 31,529 | 31,028 | 30,872 | 30,615 | 30,660 |
| Hoare & Co. - - - - | 31,278 | 31,008 | 30,310 | 29,450 | 29,607 |
| Elliot & Co. - - - - | 22,000 | 22,990 | 25,255 | 25,379 | 27,050 |
| Charrington & Co. - - | 20,290 | 18,688 | 18,328 | 17,840 | 20,423 |
| Taylor & Co. - - - - | 27,320 | 25,955 | 27,300 | 21,424 | 19,530 |
| Courage & Co. - - - | 10,723 | 10,456 | 11,532 | 12,328 | 13,016 |

* Those marked thus* brew porter only.

Quarters of Malt consumed in the undermentioned Years ending 10th October.

| By the Brewers of London and its Vicinity. | | | | | | | | | | | |
|--|---------|------|---------|------|---------|------|---------|------|---------|------|---------|
| 1831 | 692,549 | 1833 | 578,588 | 1835 | 702,533 | 1837 | 714,489 | 1839 | 750,176 | 1841 | 724,355 |
| 1832 | 604,477 | 1834 | 662,713 | 1836 | 754,313 | 1838 | 742,997 | 1840 | 776,219 | 1842 | 741,631 |
| By the Twelve principal Brewers of London. | | | | | | | | | | | |
| 1831 | 432,521 | 1835 | 427,087 | 1839 | 503,048 | 1843 | 490,179 | 1847 | 528,259 | 1851 | 517,292 |
| 1832 | 439,046 | 1834 | 470,128 | 1836 | 526,092 | 1838 | 517,940 | 1840 | 477,908 | 1842 | 541,710 |

Table of the Quantity of Malt from Barley, which paid Duty in -

| Years. | England and Wales. | Scotland. | Ireland. |
|------------------------|--------------------|-----------------|-----------------|
| | <i>Bushels.</i> | <i>Bushels.</i> | <i>Bushels.</i> |
| 1834 | 34,449,646 | 4,491,292 | 2,204,653 |
| 1835 | 36,078,855 | 4,459,553 | 2,353,645 |
| 1836 | 37,196,998 | 4,903,187 | 2,287,635 |
| 1837 | 33,692,356 | 4,583,045 | 2,275,347 |
| 1838 | 33,823,958 | 4,419,141 | 2,262,440 |
| 1839 | 33,826,016 | 4,360,363 | 1,744,550 |
| 1840 | 36,653,442 | 4,397,304 | 1,406,116 |
| 1841 | 30,956,394 | 4,058,249 | 1,149,692 |
| 1842 | 30,796,262 | 3,786,476 | 1,268,656 |
| Amount of Duties Paid: | | | |
| | £ | £ | £ |
| 1834 | 4,449,745 | 553,567 | 272,291 |
| 1835 | 4,660,185 | 551,096 | 288,602 |
| 1836 | 4,804,612 | 611,910 | 283,357 |
| 1837 | 4,351,929 | 578,515 | 286,470 |
| 1838 | 4,368,931 | 557,913 | 284,954 |
| 1839 | 4,369,193 | 552,107 | 218,503 |
| 1840 | 4,841,229 | 573,544 | 178,703 |
| 1841 | 4,198,460 | 539,572 | 151,910 |
| 1842 | 4,176,742 | 503,829 | 168,009 |

Exports in 1850, 182,480 barrels; in 1851, 191,639 barrels; declared value, 1850, 558,794*l.*, in 1851, 577,874*l.*

MALT. British beer brewing is sadly oppressed by fiscal folly and ignorance. The regulations as to the manufacture of malt are embodied in the acts 7 & 8 Geo. 4. c. 52, and 11 Geo. 4. c. 17. The former act is an admirable specimen of legislative injustice; the latter was intended to ameliorate the provisions of its predecessor, and does, in a degree, effect that object. The first contains no less than 83 clauses; and the regulations in it, though frequently repugnant to the plainest principles of common sense, are, nevertheless, enforced by 106 penalties, amounting in the aggregate to the incredible sum of 13,500*l.* How much of this is negated by the subsequent act it is not very easy to determine, though, as far as it goes, the effect of No. 2. is to stultify the regulations of No. 1. Woe to that man, however, who begins the manufacture of malt without having duly studied these incompatible acts. Having been favoured with a perusal of the genuine "instructions for officers who survey maltsters," a clear insight may be had into the actual practice of the excise; for our copy is duly emblazoned with the arms of England, and marked "by authority;" — being, moreover, of so late a date as 1842, it offers unexceptionable evidence. The necessary apparatus for the production of malt is extremely simple, — that is to say, a cistern for steeping the grain; a floor in which it may be suffered to heat and vegetate; and, lastly, a stove or kiln in which the newly-formed malt may be dried. Specific size, or force, or other arrangement, there needs none; and such is actually the condition of the malt manufacture in most countries at this day. With us, however, a very different system prevails; — the cistern or steeping vessel must be of a determinate form and construction; it must have been approved of by a supervising officer; its cubical contents must have been very accurately ascertained, by actual admeasurement, and it must be placed in such a situation that the officer gauging it may have sufficient light, and a clear open space of 48 inches, at the least, above every part of such cistern, for the purpose of facilitating the process of gauging; and, lastly, if such light be an impossibility, from local obstacles, the maltster must enter into an engagement to keep, at his own expense, lamps or candles burning, for the convenience of the officer. From what we have now said, as well as from the notoriously uncertain character of grain, it might naturally be inferred, that the process of steeping would be left entirely to the judgment of the maltster, who would determine according to his experience, and the nature of the resulting phenomena, when the grain had been steeped long enough in the water, and when it had not. The law, however, allows him no such privilege; whether the grain be old and dry, or new and moist, is all one, — "maltsters are required to keep their corn or grain covered with water for the full space of 40 hours, under the penalty of 100*l.*" Nor will any change occurring in the appearance of the grain, and seeming to require its immediate removal, justify or excuse the maltster in so doing, unless indeed he shall have anticipated the occurrence, by giving notice of his intention to do so in his original notice "to wet" — which must date 24 hours previously to commencing that operation, — and give the day, and hour of the day, for beginning the steep, — all under the usual penalty of 100*l.* Nor may he "begin to wet at any other time than between the hours of 8 in the morning and 2 in the afternoon," under a penalty of 100*l.*, nor may he take corn or grain from any cistern at any other time than between the hours of 7 in the morning and 4 in the afternoon. To empty corn or grain out of any cistern until the expiration of 96 hours from the time of the last preceding emptying of any cistern in the establishment involves a penalty of 200*l.*; and the same infliction occurs, "if the corn or grain be not emptied out of all such cisterns at one and the same time, or within three hours after the clearing of the first cistern was commenced."

Maltsters are not to mix, either on the floor or kiln, any corn or grain of one wetting with corn or grain of another wetting, under a penalty of 100*l.* What is termed the couch, or place in which the grain, after being steeped, is laid together for the purpose of germination, is a supplementary apparatus of excise ingenuity, and no way necessary to the success of the malting process. Here the grain, after having been gauged in the steep, is again to be gauged with great care; and if the maltster should tread or compress the couch, so as to diminish its bulk, a penalty of 100*l.* is imposed, though it is obvious that a power of loosening or compressing this couch according to its temperature would greatly improve the formation of malt. However, "all corn or grain emptied into the couch frame is to be laid flat and level by the maltster, and so kept for 24 hours at the least," and similarly the floors are all to be placed level on pain of 100*l.* fine, so that any experimental essay at improvement is very likely to end in the Court of Exchequer. Again, it frequently happens, or rather we should say, it generally happens, that too little water is absorbed by the grain during the operation of steeping; the consequence of which is, that after being removed from the couch to the floor, the grain desiccates, and, ceasing to germinate, speedily evolves a sickly odour, and becomes mouldy, — the incipient radicles at the same time drying and shrinking up for want of moisture: in fact, the grain withers and perishes from the effect of drought. This condition is very frequent about the third and fourth day from the couch,

and is easily and effectually put a stop to by the application of a little water. But now comes a rather awkward dilemma for the maltster: if the grain continue on the floor without being sprinkled, it is greatly damaged or altogether spoilt; if water be sprinkled upon it to restore vitality, the law says, that "corn or grain, making into malt, must not be wetted or sprinkled with water before the expiration of 12 days, or 288 hours, after the same shall have been taken from or out of the cistern, under a penalty of 200*l*." Where, however, the steep has lasted for the full period of 50 hours, and where, consequently, the want of water is less likely to be felt, the maltster may sprinkle at the end of six days, or 144 hours; but in no case less than this, — though, as we have stated, the great urgency for the sprinkling process occurs generally on the third day; and it is an undeniable fact, that in spite of the heavy risk incurred, maltsters do almost invariably sprinkle their floors at about this period, and are thus driven to the necessity of trusting in the good faith and discretion of some favourite workman, to the infinite injury of both parties. But the vast discriminating power confided to excise officers in these matters is positively incredible. "Whenever there shall be reason to suspect, from the appearance of the grain on the floor, that it has been illegally wetted or sprinkled, the officer must give immediate notice to the maltster, or his servant, of such suspicion, and make a memorandum thereof, upon the specimen paper, and in the memorandum book, mentioning whether anything, and what was stated by such maltster, or any person on his behalf;" &c. Nay, the jaundiced views of the officer are ordered to be put on record, as to an immense number of fortuitous circumstances, all of which, of course, receive an unfavourable signification: for instance, "how the kiln was loaded, and whether fed by a brisk or slow fire? — whether the house seemed in a state for running or wetting, or committing any other and what fraud? — what the trader says, and what character he bears in his concerns with the revenue?" — and so on, in the most arbitrary and unconstitutional spirit imaginable. Indeed, lest any doubt should exist concerning the opinion which the excise authorities entertain towards the trade in general, the officer is specially instructed to make sudden and unexpected returns or visits, at unusual periods, "which we call doubling on them," so as to discover any suspicious indications. Again, of the three separate gauges of malt which he may take, whether in the cistern, in the couch, or on the floor, the officer must select the largest for charging duty upon. Thus, if in the cistern he finds $78\frac{1}{2}$ bushels indicated in the couch, subsequently $81\frac{1}{2}$ indicated, and on the floor $83\frac{1}{2}$, then the latter is preferred; and so with regard to the highest wherever found — the order being that "when the cistern or couch gauge is equal to or exceeds the floor gauge, then the best cistern or couch gauge will be the charge; but if that be less than the floor gauge, then the floor gauge will be the charge." Any accident or loss arising after the cistern gauge, is therefore thrown wholly on the maltster, who, far from being able to employ his ingenuity in the improvement of his business processes, finds himself more than fully occupied in a perpetual effort to protect his interests from the rapacious grasp of fiscal regulations conceived in the most hostile spirit to that industry by which alone they exist. The malice, carelessness, or ignorance of common workmen may at any moment subject the most honest maltster in the kingdom, not merely to charges of dishonesty but even to penal inflictions; which have ceased to carry moral degradation with them, only because of the popular belief of their gross injustice. It would be impossible, nor is it requisite, to follow out or recapitulate the innumerable annoyances to which the manufacturer of malt is subjected at present: we have thus briefly noted down a few in order that the admirers of Bavarian and other foreign beers may take into account the very different state of the malt manufacture in this country, as compared with that brought about by an unrestricted liberty to use or apply any means which the nature of the grain, the condition of the atmosphere or other accidental circumstances, may require during the process of germination.

Before quitting this subject, there are, however, two considerations that require notice. The first of these is the peculiarly unwise regulation of allowing no drawback of the malt duty upon exported ale or beer, unless the same shall have been brewed from wort of a specific gravity of not less than 1.054. Now, in most of our colonies, and in all warm climates, beer, to be agreeable and refreshing, should be weaker than this minimum gravity. In fact, a specific gravity of 1.047 forms by far the best beverage for exportation to a tropical country, as it is not only less heady in its effects, but ferments more kindly and completely than in a heavier wort, and when well hopped is not liable to secondary fermentation. Nevertheless, beer of this kind, brewed in this country, and exported, suffers under the expense of the malt duty, and has to compete in the markets of our own colonies, as well as in the neutral markets of other countries, with ales brewed by American brewers, who pay no duty. The result, of course, is, that the supply of these weak beers has passed entirely out of the hands of English brewers.

The employment of malt in the rearing of cattle is the other consideration to which we alluded. This has been hitherto totally prevented by the excessive duty; for,

though some very absurd experiments have been made, with a view to decide the respective merits of malt and barley as nutritive agents, yet the only question which physiology points out as interesting and beneficial, remains without even the semblance of a trial. Malt, in a dry state, differs little or nothing from barley, except in the possession of an extremely minute quantity of a substance called diastase; but as diastase cannot exert its peculiar powers, excepting under the influence of water and a somewhat high temperature, the only conclusion to be drawn from the experiments made in feeding cattle on malt, is that the experimentalists were profoundly ignorant respecting the most important elements involved in the investigation. If, therefore, such experiments have proved that malt is no better than its equivalent in barley, for the fattening of cattle, we can only say that this fully equals our expectations, for there can be no doubt that the heat evolved during the malting process has robbed the grain of a portion of carbon, which is, consequently lost to the feeder of cattle. Malt cannot equal its equivalent of barley in nutritious power, unless we take advantage of the diastase it contains to render soluble, and therefore more easy of assimilation, not only its own starch, but also the farinaceous ingredients of other kinds of food. When ground malt, or a portion of diastase and water, are digested with starch, or anything containing it, at a temperature of 170° Fahr., the starch rapidly dissolves, and gradually passes, first, into gum or dextrine, and then into sugar. Thus, for example, if potatoes be mixed with a tenth of their weight of powdered malt, and the whole subjected to the action of water, treated as above, the resulting products will be gum and sugar in a soluble state; and, consequently, in that condition best of all suited to relieve or assist any digestive imperfection in the animal economy. Indeed, the process of digestion may then be said to have commenced, ere the food had reached the stomach of the animal, and the effects of diastase, heat and moisture, applied externally, substitute the action of the gastric juice within. For young or sickly animals, or those which it is desired to bring forward speedily to perfection, the use of malt, applied thus, cannot fail to ensure the most beneficial results. The nutritive powers of gum and sugar are very well known to physiologists, the first being largely used as food by the Moors, Bosjesmen of Southern Africa, and the inhabitants of Sendar in Dongolia; amongst whom "six ounces of gum are found sufficient for the daily support of an adult," according to Jackson; whilst in respect to sugar, it is quite notorious that, though the labour of the negroes, during the sugar season, is excessive, they nevertheless become extremely fat at that time, from the nutritive quality of the sugar they consume. If, therefore, it is desired to ascertain the true value of malt, in aiding the digestive power of an animal, it is clear that this can be done only by taking advantage of the catalytic agency of the diastase it contains, and which seems so closely to resemble the animal principle "*pepsine*," to the influence of which the action of the gastric juice is now almost universally ascribed by chemists. Nor would there be the slightest difficulty in carrying this improvement into practice as most large farmers now prepare hot mashes for their cattle; though these are, for the most part, unwisely made from carrots, turnips, and such like vegetables as contain gum and sugar ready formed by nature; whereas the indication points to those of a starch kind, where the nutritive matter is insoluble, and therefore liable to pass away from the animal unassimilated. True, indeed, the malt duty offers an impediment; but the admitted suffering of the agricultural interest is a powerful instrument of honesty in a just cause, and a drawback is no novelty to the Exchequer. There is, however, an objection of a social and moral character to be urged against the malt duty, which appears altogether unanswerable. From what we have stated concerning the action of diastase, it must be obvious that a mixture of barley and malt would make quite as good a wort as malt alone: that is to say, one part of malt and seven parts of barley mashed together would afford a wort exactly resembling that from eight parts of malt alone. Thus, then, by taking advantage of his scientific knowledge, the brewer might diminish his malt duty to one-eighth, or even less; but this the law will not allow, though, in foreign countries, it may be and is done, even though the difference in cost between barley and malt is but trifling in such places. But, strange to say, that which the legislature denies to the brewer, it freely accords to the distiller, who may use a mixture of malt and barley, in any proportion he pleases; thus indicating that ardent spirits are less injurious to the social *status* of the lower orders than beer — a perfectly untenable line of argument, but failing which necessitates the conclusion that little heed is taken of the moral sanity of the nation, so long as the vices of the people tend to replenish the exchequer. Having thus thrown together a few remarks calculated to explain the mode in which the excise duty on malt interferes with the industrial development of Great Britain, we refer to the article *BEER* for the peculiar changes which occur from the mash-tun to the finished product, as "fined" for the market. Let us here, however, notice the fact, that malt differs very largely indeed in the amount of its available constituents, which, by analysis, may be shown to range from about 62 to 70 of soluble extract per cent., — the average composition being as under: —

| | | | | | |
|------------------|---|---|---|---|------|
| Moisture | - | - | - | - | 6.5 |
| Insoluble matter | - | - | - | - | 26.7 |
| Soluble extract | - | - | - | - | 66.8 |

Now it is a remarkable illustration of the benumbing effect of excise interference, that, though these great differences exist, yet no process of analysis is adopted by any brewer of the present day, other than the uncertain indication of taste, and the still more equivocal guidance of weight per bushel,—for it cannot be called specific gravity. Therefore, although, in some of our large breweries not less than, perhaps, 100,000 quarters of malt are used every year (a single per centage upon which would equal the value of 1,000 quarters), yet no attempt is made, by direct experiment before buying, to determine the true worth of the article submitted for sale. The consequence of this system is not difficult to be foreseen; in a vast majority of cases a higher price is proportionally given for bad than for good malt; and the proper yield from the mash-tun being entirely unknown, there is no possibility of determining whether this operation has been well or ill-performed. A striking example of the errors induced by this random mode of valuing malt is now before us. Of three samples marked respectively Nos. 1, 2, and 3, the second was valued as 3s. better than the third; and the first as 2s. 4d. better than the second, the estimates being those of an eminent London brewer. The following table, however, which shows their real value, as found by analysis, demonstrates the total incorrectness of the above method:—

| | Moisture. | Insoluble matter. | Extract. |
|---------------|-----------|-------------------|----------|
| No. 1 yielded | - 6.8 | 27.5 | 65.7 |
| No. 2 | - 9.1 | 24.9 | 66.0 |
| No. 3 | - 5.7 | 27.1 | 97.2 |

So that the sample reported to be the worst is actually that which affords the largest amount of extract, though it seems that No. 2 is the best malt; but, being a twelve-month old, its content of moisture is large. The mode of estimating the true value of malt is very easy; and, but for the circumstance that brewers are afraid of the very name of chemistry, from its vulgar association with drugs, there is little doubt that, in common with every other variable article, its worth would be determined by the unerring rules of science. The day must, however, speedily come, when this coyness can no longer prove compatible with the brewing interest; and, therefore, we proceed to describe the method of executing a chemical analysis of malt. Having ground a quantity of the malt in question to powder, (and for this purpose, an ordinary coffee-mill answers perfectly,) weigh out 100 grains of the powder, and expose it for half an hour to the heat of boiling water, in an oven or compartment surrounded by that fluid; at the end of this time weigh it again; the loss indicates the quantity of moisture present in the malt. While this operation is going on, 100 grains of the same powder are to be placed in a cup, with about six ounces of cold water, and then exposed to the heat of a steam-bath, with occasional stirring. This operation may continue also for half an hour, when the whole is to be thrown upon a clear linen filter; and, as soon as the wort or fluid has drained away, the residue must be well washed with boiling water; then dried and weighed. The weight represents the amount of insoluble matter, and, consequently, if, from the total weight=100, we deduct that of the moisture and insoluble matter, the remainder must represent the proportion of soluble extract, or, in other words, the saccharine value of the malt. This, as we have stated, may be taken on an average at 66 per cent.; and if we assume the quarter of malt at 324 lbs. weight, then the total saccharine extract from the quarter becomes 213.84 lbs. avoirdupois; but as this, in taking on the form of gum and sugar, chemically combines with the elements of water, so the extract, if evaporated to dryness, would reach very nearly 231 lbs.; and this reduced to the basis of a barrel, of 36 gallons, becomes, in the language of the brewer, 87 lbs., per barrel, which, however, merely means, that the wort from a quarter of malt, if evaporated down to the bulk of a barrel, or 36 gallons, would weigh 87 lbs. more than a barrel of water. As a rule, 52½ lbs. of saccharine extract indicate 20 brewers' pounds, or give a barrel of wort, having a specific gravity = 1.0556 nearly.

There are some doubts as to the effect of retaining malt in a bruised or powdered state for any considerable period prior to mashing. By a few brewers this is deemed hurtful, though the majority seem to regard it as indifferent. We have made a few practical experiments on this subject, and find that, within a very extensive range, the process of mashing is rather improved than otherwise by exposing the malt to the action of the air, as, by this means, it not only attracts moisture from the atmosphere, and is thereby more easily commingled with the water in the mash-tun, but a portion of the gluten seems also oxidized by this exposure; and hence a finer and clearer wort is produced. A three months' exposure of bruised malt had not at all injured either the quantity or quality of the extract in our experiments. It might be supposed that the simplest mode of determining the value of malt would be to mash a portion with care,

and then ascertain the specific gravity of the solution, but, from the circumstance previously stated, this cannot be done, as water continues to combine chemically with the extract until nothing but sugar exists, and this would require many hours' exposure to a regulated temperature; hence, the process above given is both the most exact and the most expeditious. In mashing, much depends upon the kind or strength of wort desired, as well as upon the circumstance whether table beers and strong beers are brewed in the same establishment, or merely strong beers alone. Any wort weighing, in the language of the brewer, less than 15 lbs., is, properly speaking, a table or small beer wort. The wort of the common porter, drunk in this town, or London beer, weighs 20 lbs., and the strongest bottling stout is about 35. Some of the Burton and Scotch ales run, however, as high as 38 lbs. Under BREWING, the means are pointed out by which any given sample of ale or beer may be analysed so as to determine exactly the weight of the wort from which it was brewed. At present, however, we must turn our attention to the wort as existing in, and flowing from, the mash-tun. In a general way, about 10 gallons of water may be taken for every bushel of malt in the first mash; and, after well mixing the two together, the whole should be closely covered down for three hours, ere any attempt is made to draw off the wort. It is immaterial whether the water be added to the malt, or the malt to the water; but the temperature of this latter is of great importance. In mild or warm weather a heat of 175° Fahr. is sufficient; but, in winter, 180° will be requisite, as the malt then cools down the average heat more than in summer: in either case, the temperature, after mixing, should not exceed nor fall much short of 170° Fahr. At the expiration of three hours, this wort may be withdrawn into a proper vessel, or under-back, where it must be kept warm. Its specific gravity should be about 1.092, or weigh 33 lbs. per barrel more than water. So soon as the first wort has been withdrawn (and the quantity of which is seldom more than $\frac{1}{3}$ th of the water employed), another portion of water must be poured upon the malt, in the ratio of about eight gallons to the bushel of malt employed, and of a temperature somewhat higher than the first. After standing two hours this is drained away, like the first, when a quantity of boiling water is slowly trickled down upon the grains from an apparatus termed a "sparger," until the wort, which flows away, ceases to possess any appreciable gravity beyond that of water. The worts are then mixed together, in these cases, where table beer is not made, and the whole reduced, by boiling, to the desired gravity of the beer meant to be brewed. Where table beer, however, is manufactured, the strong worts are kept apart and the weak ones alone are fermented for this purpose. In both cases, the strong beers are brewed from worts having a technical weight of from 20 to 36 lbs. per barrel. It has long been supposed, that wort, as usually manufactured, consisted chiefly of sugar, but this is a great error, for there is seldom so much as one third of all the extract in wort saccharified. The ordinary proportion is, one part of grape-sugar and three of dextrose.

MALT KILN; (*Darre*, Germ.) The improved malt kiln of Pistorius is represented *fig.* 884. in a top view; *fig.* 885. in a longitudinal view and section; and

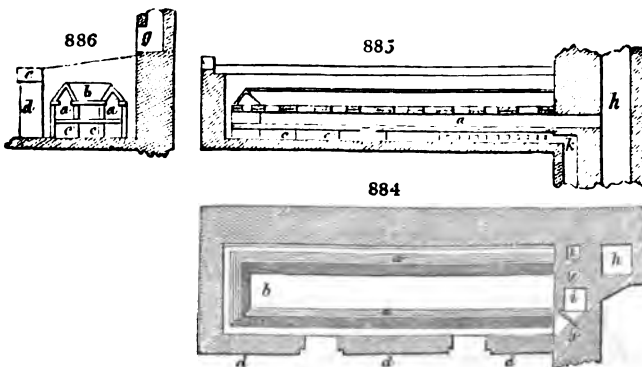


fig. 886., in transverse section. *a a*, are two quadrangular smoke flues, constructed of fire-tiles, or fire-stones, and covered with iron plates, over which a pent-house roof is laid; the whole bound by the cross pieces *b* (*figs.* 885, 886.) These flues are built above a grating *c c*, which commences at *e'*; in front of *e'* there is a bridge of bricks. Instead of such a brick flue covered with plates, iron pipes may be used, covered with semi-cylindrical tiles, to prevent the malt that may happen to fall from being burned. *d d*, are the breast walls of the kiln, 3 feet high, furnished with two apertures shut with iron

doors, through which the malt that drops down may be removed from time to time. *e* is a beam of wood lying on the breast wall, against which the hurdles are laid down slantingly towards the back wall of the kiln; *ff* are two vertical flues left in the substance of the walls, through which the hot air, discharged by open pipes laid in a subjacent furnace, rises into the space between the pent-house roof and the iron plates, and is thence allowed to issue through apertures in the sides. *g* is the discharge flue in the back wall of the kiln for the air now saturated with moisture; *h* is the smoke-pipe, from which the smoke passes into the anterior flue *a*, provided with a slide-plate, for modifying the draught; the smoke thence flows off through a flue fitted also with a damper-plate into the chimney *i*. *k* is the smoke-pipe of a subsidiary fire, in case no smoke should pass through *h*. The iron pipes are 11 inches in diameter, the air-flues *f*, 5 inches, and the smoke-pipe *h*, 10 inches square; the brick flues 10 inches wide, and the usual height of bricks.

MALTHA; *Bitume Glutinæuz*, or mineral pitch. It is a soft glutinous substance, with the smell of pitch. It dissolves in alcohol, but leaves a bituminous residuum; as also in naphtha, and oil of turpentine. It seems to be inspissated petroleum.

MANGANESE, (Eng. and Fr.; *Mangan*, *Braunsteinmetall*, Germ.) is a grayish-white metal, of a fine-grained fracture, very hard, very brittle, with considerable lustre, of spec. grav. 8.013, and requiring for fusion the extreme heat of 160° Wedgewood. It should be kept in closely stoppered bottles, under naphtha, like potassium, because with contact of air it speedily gets oxidized, and falls into powder. It decomposes water slowly at common temperatures, and rapidly at a red heat. Pure oxide of manganese can be reduced to the metallic state only in small quantities, by mixing it with lamp black and oil into a dough, and exposing the mixture to the intense heat of a smith's forge, in a luted crucible; which must be shaken occasionally to favour the agglomeration of the particles into a button. Thus procured, it contains, however, a little carbon.

Manganese is susceptible of five degrees of oxygenation:—

1. The *protoxide* may be obtained from a solution of the sulphate by precipitation with carbonate of potash, and expelling the carbonic acid from the washed and dried carbonate, by calcination in a close vessel filled with hydrogen gas, taking care that no air have access during the cooling. It is a pale green powder, which slowly attracts oxygen from the air, and becomes brown; on which account it should be kept in glass tubes, containing hydrogen, and hermetically sealed. It consists of 77.57 metal and 22.43 oxygen. It forms with 24 per cent. of water a white hydrate; and with acids, saline compounds; which are white, pink, or amethyst coloured. They have a bitter, acerb taste, and afford with hydrogenated sulphuret of ammonia a flesh-red precipitate, but with caustic alkalis, one which soon turns brown-red, and eventually black.

2. The *deutoxide of manganese* exists native in the mineral called *Braunite*; but it may be procured either by calcining, at a red heat, the proto-nitrate, or by spontaneous oxidization of the protoxide in the air. It is black; when finely pulverized, dark brown, and is convertible, on being heated in acids, into protoxide, with disengagement of oxygen gas. It consists of 69.75 metal, and 30.25 oxygen. It forms with 10 per cent. of water, a liver-brown hydrate, which occurs native under the name of *Manganite*. It dissolves readily in tartaric and citric acids, but in few others. This oxide constitutes a bronze ground in calico-printing.

3. *Peroxide of manganese*, *Braunstein*, occurs abundantly in nature. It gives out oxygen freely when heated, and becomes an oxidulated deutoxide. It consists of 63.36 metal, and 36.64 oxygen.

4. *Manganic acid*, forms green-coloured salts, but has not hitherto been insulated from the bases. It consists of 53.55 metal, 46.45 oxygen.

5. *Hypermanganic acid*, consists of 49.70 metal and 50.30 oxygen.

Ores of manganese.—There are two principal ores of this metal which occur in great masses; the peroxide and the hydrated oxide; the first of which is frequently found in primitive formations.

1. *Metalloide oxide of manganese*; *pyrolusite*, or gray manganese ore; has a metallic lustre, a steel gray colour, and affords a black powder. Spec. grav. 4.85. Scratches calc-spar. It effervesces briskly with borax at the blow-pipe, in consequence of the disengagement of oxygen gas. This is the most common ore of manganese, and a very valuable one, being the substance mostly employed in the manufacture of chloride of lime and of flint-glass. It is the peroxide. Great quantities are found near Tavistock, in Devonshire, and Launceston, in Cornwall.

2. *Braunite*, is a dark brown substance, of a glassy metallic lustre, affording a brown powder. Spec. grav. 4.8. It scratches felspar; but is scratched by quartz. Infusible at the blow-pipe, and effervesces but slightly when fused with glass of borax. It is the deutoxide. It gives out at a red heat only 3 per cent. of oxygen.

3. *Manganite*, or hydroxide of manganese; is brownish-black or iron-black, powder

brown, with somewhat of a metallic lustre. Spec. grav. 4.3. Scratches fluor spar; affords water by calcination in a glass tube; infusible at the blow-pipe; and effervesces slightly when fused with glass of borax. It consists of about 90 of deutoxide, and 10 of water.

4. *Hausmannite, black braunstein*; is brownish-black, affords a reddish brown powder. Spec. grav. 4.7; scratches fluor spar; infusible at the blow-pipe; does not effervesce when fused with borax. It is a deutoxide. This is a rare mineral, and of no value to the arts.

5. *Barytic oxide of manganese; fibrous wad*. It is a combination of deutoxide and peroxide, with some baryta.

6. *Manganese blende, or sulphuret of manganese*; has a metallic aspect; is black, or dark steel gray; spec. grav. 3.95; has no cleavage; cannot be cut; infusible, but affords after being roasted distinct evidence of manganese, by giving a violet tinge to soda at the blow-pipe. Soluble in nitric acid; solution yields a white precipitate with the ferro-cyanide of potassium. It consists of sulphur 53.65; manganese 66.35.

7. *Carbonate of manganese; dialogite*. Spec. grav. 3.4; affords a green frit by fusion with carbonate of soda; is soluble with some effervescence in nitric acid; solution when freed from iron by succinate of ammonia, gives a white precipitate, with ferrocyanide of potassium. It consists of 28 carbonic acid, 56 protoxide of manganese, 5.4 of lime, 4.5 protoxide of iron, and 0.8 magnesia.

8. *Hydrosilicate of manganese*; is a black metallic looking substance, which yields a yellowish-brown powder, and water by calcination; is acted upon by muriatic acid, but affords no chlorine. It consists of silica 25; protoxide of manganese 60; water 13.

9. *Ferriphosphate of manganese*, is brown or black. Spec. grav. 3.6; scratches fluor; affords by calcination a very little of an acid water which corrodes glass; very fusible at the blow-pipe into a black metalloïd magnetic bead; is acted upon by nitric acid; solution lets fall a blue precipitate with ferrocyanide of potassium; which tested by soda is shown to be manganese. It consists of phosphoric acid 32.78; protoxide of iron 31.90; protoxide of manganese 32.60; phosphate of lime 3.2. Another phosphate called *hureaulite*, contains 38 of phosphoric acid; 11.10 of protoxide of iron; 32.85 of protoxide of manganese, and 18 of water.

Black wad, is the old English name of the hydrated peroxide of manganese. It occurs in various imitative shapes, in froth-like coatings upon other minerals, as also massive. Some varieties possess imperfect metallic lustre. The external colour is brown of various shades, and similar in the streak, only shining. It is opaque, very sectile, soils and writes. Its specific gravity is about 3.7. Mixed with linseed oil into a dough, black wad forms a mass that spontaneously inflames. A variety from the Hartz, analyzed by Klaproth, afforded peroxide of manganese 68; oxide of iron 6.5; water 17.5; carbon 1; barytes and silica 9. The localities of black wad are particularly Cornwall and Devonshire, the Hartz, and Piedmont. I have analyzed many varieties of the black wad sold to the manufacturers of bleaching salt, and flint glass, and have found few of them so rich in peroxide of manganese as the above. Very generally they contained no less than 25 per cent. of oxide of iron, 8 or 9 of silica, about 7 of water, and the remainder amounting to only 60 per cent. of the peroxide.

M. Gay Lussac has proposed to determine the commercial value of manganese ore, by the quantity of chlorine which it affords when treated with liquid muriatic acid. He places the manganese powder in a small retort or matras, pours over it the acid, and the chlorine being disengaged with the aid of a gentle heat, is transmitted into a vessel containing milk of lime or potash water. This liquor is afterwards poured into a dilute solution of sulphate of indigo; and the quantity of chlorine is inferred from the quantity of the blue solution which is decoloured. I pass the chlorine into test solution of indigo.

The manufacturer of flint glass uses a small proportion of the black manganese ore, to correct the green tinge which his glass is apt to derive from the iron present in the sand he employs. To him it is of great consequence to get a native manganese containing as little iron oxide as possible; since in fact the colour or limpidity of his product will depend altogether upon that circumstance.

Sulphate of manganese has been of late years introduced into calico printing, to give a chocolate or bronze impression. It is easily formed by heating the black oxide, mixed with a little ground coal, with sulphuric acid. See CALICO PRINTING.

The peroxide of manganese is used also in the formation of glass pastes, and in making the black enamel of pottery. See OXALIC ACID.

The recovery of manganese in the state of peroxide for the chemical arts, in which it is so extensively consumed, has been long a desideratum in manufactures.

M. de Sussex pretends to reconvert the residuum that is left after the disengagement of chlorine or oxygen from manganese, and which is a product of little or no value, into a substance of great value, namely, that superoxide of manganese, which is peculiarly fitted, by the large proportion of oxygen it contains, to serve

the purpose of affording either chlorine or oxygen gas again, according to the process it is subsequently subjected to. The said residuary matters, after the extrication of the chlorine in the manufacture of chloride of lime, or bleaching powder, and of chlorate or hyperoxymuriate of potash, consist principally of chloride and sulphate of manganese; but as these residuums may and have been occasionally converted more or less into sulphuret of manganese when they are used to purify coal gas from its sulphur or sulphuretted hydrogen, the patentee includes not only the above sulphate and chloride, but also the sulphuret of manganese, among the waste or refuse products, which he converts into a valuable peroxide of that metal. He applies, moreover, this invention to the conversion of all oxides, carbonates, and other combinations of manganese whatever, whether native or factitious, which contain the metal in an inferior state of oxidation, into a superoxide of manganese, adapted to produce chlorine by the agency of hydrochloric acid, and oxygen by the agency either of heat alone, or of heat along with sulphuric acid.

The manner in which the said invention is to be carried into execution is as follows:— The conversion of manganese, whether combined or uncombined from a lower state of oxidation into the higher state of superoxide, is effected by two distinct operations. First, it is well known that when peroxide of manganese, called in its purest native state, pyrolusite, and also gray manganese ore, is digested with hydrochloric or muriatic acid, the oxygen of the metal combines with the hydrogen of the acid to form water, and leaves the chlorine of the acid free, while the manganese, thus partially stripped of its oxygen, combines with the rest of the hydrochloric acid to form a muriate of manganese. Likewise, when more or less dilute sulphuric acid, common salt (chloride of sodium), and peroxide of manganese, are so mixed and treated as to be made to re-act on one another, the hydrochloric acid, which is disengaged, is converted by the oxygen of the manganese into water and chlorine, while both the soda produced from the common salt, and the partially deoxidised manganese, combine with the sulphuric acid into sulphate of soda and sulphate of manganese. He converts either the chloride, sulphate, sulphuret, or carbonate, into a sesquioxide or deutoxide of manganese, by one or other of the three following processes:— First, he subjects dried chloride of manganese to a strong heat, produced either by the united action of burning fuel, and a jet or jets of an oxy-hydrogen blowpipe, or of a stream of atmospheric air thrown upon the burning fuel by a fan or other suitable impulsive power, thus forming a kind of blowpipe or blast-furnace, in which the chemical decomposition and re-action are rendered quicker and more complete. The furnace is constructed like an ordinary reverberatory furnace, with the addition of a box or chest of iron open at top, set in the fire-place, close to the bridge, which box is filled with iron turnings, borings, or other small fragments of iron, upon which, in their strongly ignited state, water is allowed to trickle or drop down slowly from a pipe, so as to be decomposed, and to disengage a stream of hydrogen, which is impelled over the bridge of the furnace upon the hearth by means of a fan or other blowing machine acting at the entrance or door of the fire-place. The manner in which the furnace is regulated is as follows: The fuel, either common coals, coke, anthracite, wood, turf, &c., is first lighted upon the grate, and being subjected to the blast of air, soon creates such a temperature as to raise the box of iron turnings to a red-white heat, in which state the water being allowed to trickle down into the said box, is decomposed with the copious disengagement of hydrogen gas. The chloride of manganese may be exposed on the hearth of the reverberatory furnace either in a more or less concentrated liquid state, or in a dry state, to the action of the intensely powerful flame, generated as above described, and becomes thereby decomposed by the hydrogen, with the disengagement of its chlorine in the state of hydrochloric acid or muriatic acid gas, while the remaining protoxide of manganese becomes at the same time oxidized into the deutoxide. The hydrochloric acid gas disengaged is condensed by means of vaults or large chimneys, containing wet coke or flint nodules in the way often practised in soda manufactories. Instead of the above described hydrogen flame, he employs sometimes a simple reverberatory furnace with ordinary fuel, either with or without blast, in which he resolves the chloride of manganese into hydrochloric acid and peroxide of manganese, but he prefers the compound flame of hydrogen and ordinary fuel.

In his second process, instead of acting on chloride of manganese by the flame of combustible matter on the hearth of a furnace, he subjects the chloride of manganese, put into fire clay retorts, to an intense heat, by which he expels the chlorine partly in the state of hydrochloric acid, and partly of chlorine, and the manganese left in the retorts may be afterwards peroxidized by a process to be presently described.

In his third process he mixes together chloride of manganese and carbonate of lime, or quicklime, in the proper equivalent proportions for mutual decomposition, and he subjects that mixture to the strong heat of the above described compound hydrogen flame, whereby he obtains a mixture of chloride of calcium (muriate of lime), and oxide

of manganese, which he peroxidizes by a process about to be described. Magnesia, or magnesian limestone, may be substituted for lime, or its carbonate, in this process. When the carbonate of lime is used, with rather too low a heat in the furnace, carbonate of manganese may be formed. In all cases, the resulting mixture of chloride of calcium or magnesium, and oxide of manganese, is to be treated with water, so as to dissolve out the said chlorides, and leave the oxide of manganese.

The following is his plan of decomposing sulphate of manganese, however formed, so as to obtain from it an oxide of manganese, to be per-oxidised by an after process:—

He mixes the sulphate of manganese with sawdust, ground coke or charcoal, or any like combustible matter, only in such proportion as to be capable of decomposing the sulphuric acid present, when the mixture is subjected to a strong calcining heat in retorts of iron, or preferably of fire-clay, whereby he obtains a sulphuret of manganese, mixed with more or less oxide of manganese. He finishes this operation, by introducing into the said residuary mixture, fragments of coke, charcoal or coal, and continuing the application of heat for some time, while the mouth of the retort is left open, whereby he desulphurates the manganese in a greater or less degree, and converts its sulphuret into an oxide. In case any salt, or other compound of soda, should have been mixed with the sulphate of manganese, the soda compound is to be separated from the manganese by means of water, after the above described calcination in the retorts. The sulphuret of manganese sometimes produced in coal gas works, as a residuum of the purification of the gas, may be desulphurated in retorts as above described, or preferably by exposing it mixed with pieces of coke, charcoal, coal or wood, on the hearth of the above described reverberatory hydrogen furnace. The coke, &c. should be used not in powder, but in distinct pieces, whereby it may be readily separated from the oxide of manganese afterwards, either by a sieve or other suitable means.

The following is his manner of performing the second operation, or series of operations, whereby he converts the deutoxide of manganese produced in the before-described processes, as also all lower oxides and the carbonated oxide of manganese, whether natural or factitious, into a superoxide fit for affording chlorine by the action of hydrochloric acid, and oxygen by heat; and he produces the said peroxidization in one or other of the three following ways. First, he converts the said oxides or carbonates from their lower to the much higher state of oxidation of an acid of manganese, by subjecting a mixture of them with alkaline matters, such as potash or soda, either caustic or carbonated, on the hearth of a reverberatory furnace, to the joint agency of heat and atmospherical oxygen, which may or may not be impelled and diffused by mechanical means. He finds that about one part of the oxide or carbonate of manganese, mixed with about three parts of alkaline matter, forms a suitable proportion for the production of an acid of manganese. The said mixture fuses with the production of a manganate or permanganate of potash or soda, according as one or other alkali has been used in the mixture. The fused mass is run or laded out of the furnace, and when cooled is dissolved in hot water. This solution, of what is sometimes called chameleon mineral, on being exposed freely to the air, becomes decomposed, by the absorption of carbonic acid gas, into peroxide of manganese, which precipitates in a black powder, and carbonated alkali which remains in solution. Where carbonic acid gas can be conveniently procured at a very cheap rate, the above described decomposition of the chameleon mineral may be promoted by a due application of the said acid gas. Or, otherwise, the alkaline bicarbonates obtained from a preceding decomposition of chameleon mineral may be employed for decomposing a fresh-made solution of the said chameleon, whereby a precipitate of peroxide of manganese is immediately obtained. The supernatant alkaline liquor is in all cases decanted or run off, and reserved for subsequent use. He also decomposes chameleon mineral with the production of peroxide of manganese by the action of various organic products, such as starchy or gummy matters, but he greatly prefers to effect the desired production of peroxide of manganese by carbonic acid gas, or an alkaline bicarbonate. His second method of producing peroxide of manganese from its lower oxide or carbonate, consists in subjecting a mixture of about one equivalent chemical proportion of either of these, and about one equivalent of lime, to the chlorine expelled by heat from chloride of manganese contained in the retort, as heretofore described. Or, by treating one equivalent proportion of that lower oxide of manganese, called by chemists sesquioxide or deutoxide, with one half of an equivalent proportion of aqueous or liquid hydrochloric acid, he obtains simultaneously one half of an equivalent proportion of protochloride of manganese in solution, and one half an equivalent of peroxide in the state of a black powder. A like re-action, with the production of a solution of protochloride of manganese, and black peroxide, may be effected by treating the said sesquioxide with aqueous hydrochloric acid in one vessel, and transmitting therefrom the chlorine disengaged into another vessel, containing a like sesquioxide in a moist state.

His third method of converting into peroxide of manganese its lower oxide or carbonate consists in directing over the surface of either of these, in a moist state, the deutoxide of azote, frequently called nitrous gas, which is obtained as a waste product in certain chemical operations, as in the manufacture of oxalic acid, or nitrate of lead, or of copper, &c.

In this case, the nitrous gas becomes reduced to a lower state of oxidation, and by imparting oxygen to the lower oxide of manganese, converts it into peroxide.

MANGANESE, OXIDE OF; for a simple method of ascertaining the value of this substance in the production of chlorine, and the manufacture of the chlorides and chlorates, see **CHEMISTRY SIMPLIFIED**, in **SUPPLEMENT**.

MANGLE. (*Calandre*, Fr.; *Mangel*, Germ.) This is a well known machine for smoothing table cloths, table napkins, as well as linen and cotton furniture. As usually made, it consists of an oblong rectangular wooden chest, filled with stones, which load it to a degree of pressure that it should exercise upon the two cylinders on which it rests, and which, by rolling backwards and forwards over the linen spread upon a polished table underneath, render it smooth and level. The moving wheel, being furnished with teeth upon both surfaces of its periphery, and having a notch cut out at one part, allows a pinion, uniformly driven in one direction, to act alternately upon its outside and inside, so as to cause the reciprocating motion of the chest. This elegant and much admired English invention, called the mangle-wheel, has been introduced with great advantage into the machinery of the textile manufactures.

Mr. Wareup, of Dartford, obtained a patent several years ago for a mangle, in which the linen, being rolled round a cylinder revolving in stationary bearings, is pressed downwards by heavy weights hung upon its axes, against a curved bed, made to slide to and fro, or traverse from right to left, and left to right, alternately.

Mr. Hubie, of York, patented in June, 1832, another form of mangle, consisting of three rollers, placed one above another in a vertical frame, the axle of the upper roller being pressed downwards by a powerful spring. The articles intended to be smoothed are introduced into the machine by passing them under the middle roller, which is made to revolve by means of a fly wheel; the pinion upon whose axis works in a large toothed wheel fixed to the shaft of the same roller. The linen, &c. is lapped as usual in protecting cloths. This machine is merely a small **CALENDER**.

MANIFOLD BELL-PULL. (*Exhibition*.) 45. *Bryden and Sons, Rose Street, Edinburgh, Inventors and Manufacturers*.—A manifold bell-pull constructed upon an entirely new plan, by which one pull is made to ring bells in any number of rooms. When the pointer is placed opposite to any name on the dial plate, and knob pulled out, the bell is then rung in the room indicated.

An improved circular telegraph bell having two dials, numbered in the same manner, by means of which eight different clerks or workmen may be called.

An air signal mouth-piece and bell, by blowing into the mouth-piece the bell is rung, at any distance less than 1,000 feet. This is an improved method of ringing a bell in places too distant or not suited for working cranks and wires.

A single voice tube mouth-piece and bell-pull. When drawn out, the tube orifice is opened, and the signal bell being rung, the attendant is called to the other end of the tube.

A revolving mouth-piece for voice tubes, with bell-pull combined; contrived so that one mouth-piece connects with six or any greater number of voice tubes, and at the same time with a similar number of bells.

Specimen of a self-closing valve mouth-piece for voice tube; and of a spring covered mouth-piece for voice tube.

MANIOC, is the Indian name of the nutritious matter of the shrub *jatropha manihot*, from which *cassava* and *tapioca* are made in the West Indies.

MANNA, is the concrete saccharine juice of the *Fraxinus ornus*, a tree much cultivated in Sicily and Calabria. It is now little used, and that only in medicine.

MANUFACTURING INDUSTRY, DURING THE LAST AND PRESENT CENTURY, by Wm. Fairbairn, Esq., F. R. S., Member of the Institute of France.—If we take, I will not say a statistical, but a very cursory view of the recent position of Manchester and the surrounding districts, and compare it with what it was at the close of the last and the commencement of the present century, we shall find that at that period the useful and industrial arts were comparatively of little importance. We shall also find that the grafts of a new, and above all others an important branch of manufacturing industry springing into existence. I have no returns of the state of our manufacturing industry at that period, but the writings of one of our earliest and most intelligent spinners, to whom this country is indebted for many improvements in machinery, Mr. John Kennedy, informs us, that the spinning of cotton yarn antecedent to the year 1768, was of an exceedingly limited description. That gentleman in his account of the rise

and progress of the cotton trade, stated that the handloom as a machine remained stationary for a great number of years without any attempt at improvement until 1750, when Mr. John Kay, of Bolton, first introduced the fly-shuttle, and that the spinning of cotton yarn from that period, and for many years previous, was almost entirely performed by the family of the manufacturer at his own house. This united and simple process went on till it was found necessary to divide their labours, and to separate the weaving from the spinning, and that again from the carding and other preparatory processes. This division of labour, as Mr. Kennedy truly says, led to improvements in the carding and spinning, "by first introducing simple improvements in the hand instruments, with which they performed these operations, till at length they arrived at a machine, which, though rude and ill-constructed, enabled them considerably to increase their produce." Thus it was that improvements, and the division of labour, first led to the factory system, and that splendid and extensive process which at the present moment and for many years to come will affect the destinies of nations. From 1750 to 1770, when Mr. Hargreaves, of Blackburn, first introduced his spinning Jenny (by means of which a young person could work from ten to twenty spindles instead of one), there was little or no change, but a very material alteration took place shortly after the introduction of these improvements, which were immediately followed by Mr. Arkwright's machinery for carding and roving. These accompanied by the introduction of Mr. Crompton's mule, in 1780, may be justly considered to constitute the origin of the factory system, which has now grown to such colossal dimensions, as to render it one of the most important and most extensive systems of manufacture ever known in the history of ancient or modern times. Mr. Arkwright built his first mill at Cromford, in Derbyshire (I again quote from Mr. Kennedy) "in 1771. It was driven by water, but it was not till 1790, or some time after, when the steam engine of Watt came into use, that the cotton trade advanced at such an accelerated speed, as to render its increase and present magnitude almost beyond conception. This immense extension is not only a subject of deep interest to the philosopher and statesman, but one which is likely to furnish a large field of observation for the future historian of his country." I will not trouble you with the statistics of the cotton trade as it now exists, but simply observe, as many of you are doubtless better informed on this subject than myself, that I am within the mark, when I state that not less than 31,500 bales of cotton are consumed weekly, in the two kingdoms, England and Scotland; that nearly 21,000,000 spindles are almost constantly in motion, spinning upwards of 105,000,000 hanks, or 50,000,000 miles of yarn per day—in length sufficient to circumscribe the globe 2,000 times. Out of this immense production about 131,000,000 pounds of yarn are exported; the remainder is converted into cloth, lace and other textile fabrics. This marvellous increase, this immense extent of production could not be effected without considerable changes in the prospects of the moral as well as the physical condition of society. It has entirely changed the position of the resident population of the district; and the secluded valleys, farm-houses and cottages, the beauties of a Lancashire landscape of the last generation, are rapidly giving way to the conversion of villages into populous towns, with innumerable erections which resound with the busy hum of the spindle and the shuttle. Along with these changes we see a new generation springing into existence, factories, steam-engines, and tall chimneys rising in every direction, and the noise and smoke which meet the eye and the ear of the stranger at every step give evidence of the activity and prosperity of the industrious hive, which at some future time in English history will announce to succeeding generations the inventions and the discoveries of the nineteenth century.

In this attempt to place before you a short account of the use and progress of our national industry, I must not forget that yarn, however finely and dexterously spun is not cloth; and here we enter upon another and equally ingenious process. The yarn must be woven before it is fit for use, and we shall be weaving one of the most interesting as well as elaborate operations of the useful arts. I need not inform you that the ancient Hindoos, Egyptians, and probably the early Chinese, converted their yarn into cloth. The Indian and Oriental department of the Great Exhibition exhibited the mode and primitive character of their looms and other implements, which have been handed down from generation to generation from the earliest periods, without change or improvement to the present day. Looms of this rude construction were introduced into Europe during the first glimpses of civilization, and for many centuries even the most advanced nations were content to use the same instruments, almost without improvement, until the introduction of the flying shuttle and the subsequent invention of Hall and Arkwright opened a new and untrodden field for improvements in every department of art and manufacture. Power looms at that period were unknown, and although attempts were made by Mr. Cartwright, as early as 1774, to convert the hand loom into a machine to be moved by power, it was not until the beginning of the present century that the power-loom assumed its present form, and presented that intelligence of

structure which rendered it self-acting, and enabled it to compete with the hand-loom weaver. From that time (about 1810 or 1812), we may date the commencement of that increase to which that important branch of our manufacture was extended. The improvements introduced by Mr. Bennet Woodcroft and others for weaving twills and similar fabrics created new expedients and applications, and greatly increased the demand of this description of manufactures, whilst the inventions of Jacquard for weaving figured cloth startled every one with their extreme ingenuity and beauty, and accomplished the perfection of machinery for the production of textile fabrics. The increase and extent of cloth manufactured from power-looms may be estimated from official returns, kindly furnished by Mr. Leonard Horner. There are now at work in the United Kingdom above 250,000 power-looms. Now as each loom will upon the average form five to six pieces of cloth per week, each piece 28 yards long, say 25 yards a day per loom, we have 250,000, which multiplied by 25 gives 6,250,000 yards, or 3,551 English miles of cloth per day, the distance between Liverpool and New York.

Only think of the importance and extent of a manufacture that employs upwards of 12,000 hands in weaving alone, supplying from that source (the power-loom) an annual produce of cloth that would extend over a surface in a direct line of upwards of 1,000,000 miles.

But although much has been done, much has yet to be accomplished before the supply equals the demand. It must appear obvious to those who have studied and watched the unwearied invention and continued advancement which has signalised the exertions of our engineering and mechanical industry. But neither difficulties nor danger, however formidable, can stand against the indomitable spirit, skill, and perseverance of the English engineer; nor will it be denied that the ingenuity and never-failing resources of our mechanical population are not only the sinews of our manufacture, railways and steam boats, but the pride and glory of our own country.

It is for this important class, that I have ventured to address you, and I trust the time is not far distant, when we shall witness establishments suitable for their education, such as will teach them to reason and to think, and to impart that knowledge essential to a more correct acquaintance with physical truth, and a clearer conception of the varied manipulations of those arts in which consist the true interests of the country. — *Lecture at Manchester.*

MANURE. A patent for an excellent article of this kind was obtained in May, 1842, by J. B. Lawes, Esq., for a full description of which the reader is referred to the article COPROLITES. He decomposes bones, apatite, and other subphosphates of lime by mixing them in powder with as much sulphuric acid as will liberate enough of the phosphoric to dissolve the phosphate of lime. The free phosphoric acid is thereby ready to combine with the various alkaline earths contained in the soil, while the phosphate of lime is brought to a state of more minute division than is possible by mechanical means. Mr. Lawes also proposes to mix the above soluble superphosphate with such alkalis as are deficient in the soil, and thus to form a manure adapted to fertilise it. His third improvement in manure is the formation and application of a liquor of flints, for such soils as are deficient in soluble silica. The last compound he considers to be valuable for grounds much cropped with wheat and other cereals that require a good deal of silica for their growth.

It is greatly to be regretted, that this most important subject of scientific research, has hitherto been treated too much in a one-sided manner; that is, either by individuals little conversant with practical farming, or by farmers little acquainted with the nature of soils, and the changes produced on them by the cultivation of different orders of plants.

Under the auspices of the British Association, Professor Liebig, in the year 1840, first promulgated his views on agriculture, from which date we may trace a spirit of investigation into it, such as had not previously existed in this country. Among other labourers in this field, we must state that Mr. J. B. Lawes, of Rothamstead in Hertfordshire, was occupied several years prior to the first edition of Professor Liebig's work, in investigating the action of different chemical combinations when applied as manures, to the most important crops of the farm; and having ever since continued his experimental researches with all the lights of science, with which he is familiar, aided by Dr. J. H. Gilbert, a skillful analytical chemist, he has been able to arrive at conclusions of greater value and precision than the merely theoretical determinations of the German professor. In the course of this inquiry, the whole tenour of the results of Messrs. Lawes and Gilbert, and also of information derived from intelligent agricultural friends, upon every variety of land in Great Britain, has forced upon them opinions different from those of Professor Liebig, on some important points; and more especially, in relation to his so-called "mineral theory," which is embodied in the following sentence, to be found at page 211. of the third edition of his work on Agricultural Chemistry; where he says "the crops on a field diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it in manure."

Of the vast importance, both in a scientific and a practical point of view, of correct

ideas on the subject here at issue, a judgment may be formed from the manner in which the professor himself speaks of the mineral theory in the new edition of his letters on chemistry. Thus at page 48C., he says of the agriculturists of England, that "sooner or later they must see that in the so-called mineral theory in its development and ultimate perfection lies the whole future of agriculture."

"Looking upon the subject in a chemical point of view only, it would seem that an analysis of the soil upon which crops were to be experimentally grown, as well as a knowledge of the composition of the crop, should be the first points ascertained, with the view of deciding in what constituents the soil was deficient; and at the commencement of our more systematic course of field experiments, the importance of these points was carefully considered. When we reflect, however, that an acre of soil six inches deep may be computed to weigh about 1,344,000 lbs. (though the roots of plants take a much wider range than this), and taking the one constituent of ammonia or nitrogen as an illustration, that in adding to this quantity of soil a quantity of ammoniacal salt, containing 100 lbs. of ammonia, which would be an unusually heavy and very effective dressing, we should only increase the percentage of ammonia in the soil by 0.0007, it is evident that our methods of analysis would be quite incompetent to appreciate the difference between the soil before and after the application, — that is to say, in its state of exhaustion, and of highly productive condition, so far as that constituent is concerned; and from our knowledge of the effects of this substance on wheat, we may confidently assert that the quantity of it supposed above would have given a produce at least double that of the unmanured land. The same kind of argument might, indeed, be adopted in reference to the more important of those constituents of a soil which are found in the ashes of the plants grown upon it, and we determined, therefore, to seek our results in another manner. Indeed, the imperfection of our knowledge of the productive quality of a soil, as derived from its percentage composition, has been amply proved by the results of analysis which have been published during the last ten years; and in corroboration we need only refer to the opinions of Professor Magnus on this subject, who, in his capacity of chemist to the 'Landes-Oekonomie Kollegium' of Prussia, has published the results of many analyses of soils. The truth is, that little is as yet known of what a soil either is, or ought to be, in a chemical point of view; but when we call to mind the investigations of Professor Mulder, in relation to the organic acids found in soils, and of Mr. Way and others, as to the chemical and physical properties of soils, in relation to the atmosphere, and to saline substances exposed to their action in solution, we may at least anticipate for chemistry that she will ere long throw important light on this interesting but intricate subject.

"In our field experiments, then, we have been satisfied with preserving specimens of the soils which were to be the subjects of them, and have sought to ascertain their deficiency, in regard to the production of different crops, by means which we conceive to be not only far more manageable, but in every way more conclusive and satisfactory in their result. To illustrate,—what is termed a rotation of crops is at least of such universality in the farming of Great Britain, that any investigation in relation to the agriculture of that country may safely be grounded on the supposition of its adoption. Let us, then, direct attention for a moment to some of the chief features of rotations. What is called a *course* of rotation is the period of years which includes the circle of all the different crops grown in that rotation or alternation. The crops which thus succeed each other, and constitute a rotation, may be two, three, four, or more, varying with the nature of the soil and the judgment of the farmer; but whatever *course* be adopted, no individual crop — wheat, for example, is grown immediately succeeding one of the same description, but it is sown again only after some other crops have been grown, and at such a period of the rotation, indeed, as by experience it is known that the soil will, by direct manure or other means, have recovered its capability of producing a profitable quantity of the crop in question.

"On carefully considering these established and well known facts of agriculture, it appeared to us that, by taking soils either at the end of the rotation, or at least at that period of it when in the ordinary course of farming farm-yard manure would be added before any further crop would be grown, we should then have the soils in what may be termed a *normal*, or, perhaps better still, a *practically* and *agriculturally* exhausted state.

"Now, if it is found, in the experience of the farmer, that land of any given quality with which he is well acquainted, will not, when in this condition of practical exhaustion, yield the quantity he usually obtains from it of any particular crop, but that after applying farm-yard manure it will do so, it is evident that if we supply to different plots of this *exhausted land* the constituents of farm-yard manure both individually and combined, and if by the side of these plots we also grow the crop both without manure of any kind and with farm-yard manure, we shall, in the comparative results obtained, have a far more satisfactory solution of the question as to what constituents were, in this ordinary course of agriculture, most in defect in respect to the proportion of the particular

crop experimented upon, than any analysis of the soil could have given us. In other words, we should have before us very good ground for deciding to which of the constituents of the farm-yard manure the increased produce was mainly due on the plot provided with it, in the case of the particular crops: not so, however, unless the soil had been so far exhausted by previous cropping as to be considered *practically* unfit for the growth of the crop without manure. We lay particular stress on this point, because we believe that the vast discrepancy in the results of comparative trials with different manures, by different experiments, arises more from irregularity in what may be called the *floating* capital of the soil than from irregularities in the original character of the soil itself, or from any other cause, unless we include the frequent faulty methods of application.

"It is, then, by this *synthetic* rather than by the analytic method that we have sought our results; and in the carrying out of our object we have taken *wheat* as the type of the cereal crops, *turnips* as the type of the *root crops*, and beans as the representative of the *Leguminous* corn crop most frequently entering into rotation; and having selected for each of these a field which, agriculturally considered, was *exhausted*, we have grown the same description of crop upon the same land, year after year, with different chemical manures, and in each case with one plot or more continuously unmanured, and one supplied every year with a fair quantity of farm-yard manure. In this way 14 acres have been devoted to the continuous growth of wheat since 1843, 8 acres to continuous growth of *turnips* from the same date, and 5 to 6 acres to that of leguminous corn crops since 1847. And of field experiments, beside these, which amount in each year to from 30 to 40 on wheat, upwards of 90 on turnips, and 90 to 30 on beans, others have been made, viz., some on the growth of clover, and some in relation to the chemical circumstances involved in an actual course of rotation, comprising turnips, barley, clover, and wheat, grown in the order in which they are here stated.

"It may be stated, too, that in addition to these experiments on wheat, and the other crops usually grown upon the farm, as above referred to, we have for several years been much occupied also with the subject of the feeding of animals, viz. hullocks, sheep, and pigs, — as well as in investigating the functional actions of the growing plant in relation to the soil and atmosphere; and in connection with each of these subjects much laboratory labour has constantly been in progress.

"The scope and object of our investigation has been therefore to examine in the field, the feeding shed, and the laboratory, into the chemical circumstances connected with the agriculture of Great Britain in its four main features; namely —

"First, the production of the cereal grain crops; secondly, that of root crops; thirdly, that of the leguminous corn and fodder crop; and fourthly, and lastly, that of the consumption of food on the farm for its double produce of meat and manure.

"So much then for the rationale and general plan of the experiments themselves, and we now propose to call attention to some of the results which they have afforded us.

"Hitherto, only part of the results of the wheat experiments of the harvests of 1844, 1845, and 1846, and of these seasons only, have been published; those on turnips, only for the seasons 1843, 1844, and 1845; those on the leguminous crops not at all as yet; and those on feeding, only as far as sheep are concerned, and chiefly too in relation to the one point only of the increase of *live weight* obtained from a given quantity of food, or its constituents. Of the laboratory results, but few have been given in relation to any of these branches up to the present time. The vast accumulation of results, indeed, will necessarily still further postpone the publication of them in any extended form; and hence it seems the more desirable to take advantage of the present opportunity to attempt to bring together into one view some of the general indications which have been arrived at in relation to a few important points.

"With this view, it is to the field experiments on wheat that we shall chiefly confine our attention on this occasion; for wheat, which constitutes the principal food of our population, is with the farmer the most important crop in his rotation, all others being considered more or less subservient to it; and it is, too, in reference to the production of this crop in agricultural quantity that the mineral theory of Baron Liebig is perhaps more prominently at fault than in that of any other. It is true, that in the case of vegetation in a native soil, manured by art, the mineral constituent of the plants being furnished from the soil, the atmosphere is found to be a *sufficient* source of the nitrogen and carbon; and it is the supposition that these circumstances of *natural vegetation* apply equally to the various crops when grown *under cultivation* that has led Baron Liebig to suggest that, if by artificial means we accumulate within the soil itself a sufficiently liberal supply of those constituents found in the ashes of the plant, essentially soil constituents, we shall by this means be able in all cases to increase thereby the assimilation of the vegetable or atmospheric constituents in a degree sufficient for agricultural purposes. But agriculture is itself an *artificial* process; and it will be found that, as regards the production of wheat more especially, it is only by the accumulation within the soil itself

of nitrogen naturally derived from the atmosphere, rather than of the peculiarly soil constituents, that our crops of it can be increased. Mineral substances will, indeed, materially develop the accumulation of vegetable or atmospheric constituents when applied to some of the crops of rotation; and it is thus chiefly that these crops become subservient to the growth of the cereal grains, but even in these cases it is not the constituents, as found collectively in the ashes of the plants to be grown, that are the most efficient in this respect: nor can the demand which we find thus made for the production of crops in agricultural quantity be accounted for by the mere idea of supplying the actual constituents of the crop. It would seem, therefore, that we can only arrive at correct ideas in agriculture by a close examination of the actual circumstances of growth of each particular crop when grown under cultivation. We now turn to the consideration of our experiments upon this subject. It has been said that all the experimental fields were selected when they were in a state of agricultural exhaustion. The wheat fields, however, after having been manured in the usual way for turnips at the commencement of the previous rotation, had then grown barley, peas, wheat, and oats, without any further manuring; so that when taken for experiment in 1844, it was, as a grain-producer, considerably more exhausted than would ordinarily be the case. It was, therefore, in a most favourable condition for the purposes of our experiments.

"In the first experimental season, the field of 14 acres was divided into about 20 plots, and it was by the mineral theory that we were mainly guided in the selection of manures: mineral manures were therefore employed in the majority of cases. Ammonia, on the other hand, being then considered as of less importance, was used in a few instances only, and in these in very insignificant quantities. Rape-cake, as being a well recognised manure, and calculated to supply, besides some minerals and nitrogen, a certain quantity of carbonaceous substance in which both corn and straw so much abound, was also added to one or two of the plots.

TABLE I.—Harvest 1844. Summary.

| Description of the Manures. | Dressed Corn per Acre, in Bushels and Pecks. | | Total Corn per Acre, in lbs. | Straw per Acre, in lbs. |
|---|---|--------|---------------------------------------|-------------------------------|
| | bush. | pecks. | lbs. | lbs. |
| Plot 3. Unmanured - - - - | 16 | 0 | 923 | 1120 |
| " 2. 14 tons of farm-yard manure - - - | 22 | 0 | 1276 | 1476 |
| " 4. The ashes of 14 tons of farm manure - | 16 | 0 | 888 | 1104 |
| " 8. Minimum produce of 9 plots, with artificial mineral manures - | 16 | 1 | 980 | 1160 |
| Superphosphate of lime 350 lbs. - | | | | |
| Phosphate of potass 364 lbs. - | | | | |
| Plot 15. Maximum produce of 9 plots with artificial mineral manures - | 17 | 3½ | 1096 | 1240 |
| Superphosphate of lime 350 lbs. - | | | | |
| Phosphate of magnesia 168 lbs. - | | | | |
| do. potass 150 lbs. - | | | | |
| Silicate do. 112 lbs. - | | | | |
| Mean of the 9 plots with artificial mineral manures - | 16 | 9½ | 1009 | 1155 |
| Mean of 3 plots with mineral manures, and 65 lbs. each of sulphate of ammonia - - - | 21 | 0 | 1275 | 1423 |
| Mean of 2 plots with mineral manures, and 150 lbs. and 190 lbs. of rape-cake respectively | 18 | 1½ | 1078 | 1201 |
| Plot 18. With complex mineral manure, 65 lbs. of sulphate of ammonia, and 150 lbs. of rape-cake | 22 | 3½ | 1368 | 1768 |

"The indications of the table are seen to be most conclusive, as showing what was the character of the exhaustion which had been induced by the previous heavy cropping, and what, therefore, should be the peculiar nature of the supply in a rational system of manuring. If the exhaustion had been connected with a deficiency of mineral constituents, we might reasonably have expected that by some one at least of the nine mineral conditions,—supposing in some cases an abundance of every mineral constituent which the plant could require,—this deficiency would have been made up; but it was not so.

"Thus, taking the column of bushels per acre as given in this summary as our guide, it will be seen that whilst we have without manure only 16 bushels of dressed corn, we

have by farm-yard manure 22 bushels. The *ashes* of farm-yard manure give, however, no increase whatever over the unmanured plot. Again, out of the 9 plots supplied with artificial mineral manures, we have in no case an increase of 2 bushels by this means; the produce of the average of the 9 being not quite 17 bushels. On the other hand, we see that the addition to some of these purely mineral manures of 65 lbs. of sulphate of ammonia—a very small dressing of that substance, and containing only about 14 lbs. of ammonia—has given us an average produce of 21 bushels. An insignificant addition of rape-cake too, to manures otherwise ineffective, has given us about 18½ bushels; and when, as in plot 18., we have added to the inefficient mineral manures 65 lbs. of ammoniacal salts, and a little rape-cake also, we have a produce greater than by the 14 tons of farm-yard manure.

“The quantities of rape-cake used were small, and the increase attributable to it also small, but it nevertheless was much what we should expect when compared with that from the ammoniacal salts, if, as we believe is the case, the effect of rape-cake on *grain-crops* is due to the nitrogen it contains.

“Indeed, the coincidence in the slight or non-effect throughout the mineral series on the one hand, and of the marked and nearly uniform result of the nitrogenous supply on the other, was most striking in the first year’s experimental produce, and such as to lead us to give to nitrogenous manures in the second season even greater prominence than we had done to minerals in the previous one. This is in some respects, perhaps, to be regretted, as had we kept a series of plots for some years continuously under minerals alone, the evidence, though at present sufficiently conclusive, would have carried with it somewhat more of *systematic* proof.

“In Table II. we have given a few results selected from those obtained at the harvest of 1845, the second of the experimental series. By the table it is seen that we have, at the harvest of 1845, a produce of rather more than 23 bushels without manure of any kind, instead of only 16 as in 1844; and in like manner the farm-yard manure gives 32 bushels in 1845, and only 23 in 1844. We have shown in a former number of the Journal how clearly these differences can be traced to variations in the climatic character of the *season*, but this is not the point under consideration just now.

TABLE II.—Harvest 1845. Selected Results.

| Description and Quantities of the Manures per Acre. | Dressed Corn per Acre, in Bushels and Pecks. | | Total Corn per Acre, in lbs. | Straw per Acre, in lbs. |
|---|--|--------|------------------------------|-------------------------|
| | bush. | pecks. | lbs. | lbs. |
| Section I. | | | | |
| Plot 3. No manure - - - - - | 23 | 0½ | 1441 | 2712 |
| “ 2. 14 tons of farm-yard manure - - - - - | 32 | 0½ | 1967 | 3915 |
| Section 2. | | | | |
| “ 5a. No manure - - - - - | 22 | 2¼ | 1431 | 2684 |
| “ 5b. Top-dressed with 252 lbs. of carbonate of ammonia (dissolved) at 3 times, during the spring - - - - - | 26 | 3¾ | 1732 | 3599 |
| Section 3. | | | | |
| “ 9. { Sulphate of ammonia 168 lbs. } top-dressed | 33 | 1½ | 2131 | 4058 |
| “ { Muriate of ammonia 168 lbs. } at once | | | | |
| “ 10. { Sulphate of ammonia 168 lbs. } top-dressed | 31 | 3¼ | 1980 | 4266 |
| “ { Muriate of ammonia 168 lbs. } at 4 times | | | | |

“We assume, then, 23 bushels or thereabouts to be the standard produce of the soil and season, without manure, during this second experimental year; and as part of plot 5. (previously manured with superphosphate of lime), and which is now, also, without manure, gives rather more than 22½ bushels of dressed corn, the correctness of the result of plot 3., the permanently unmanured plot, is thereby fully confirmed.

“This plot No. 5., previously two-thirds of an acre, was, in this second year, divided into two equal portions; one of these (‘plot 5a’) being, as just said, unmanured, and the other (‘plot 5b’) having supplied to it in solution, by top-dressings during the spring, the *medicinal carbonate of ammonia*, at the rate of 250 lbs. per acre; and it is seen that we have, by this pure but highly volatile ammoniacal salt alone, the produce raised from 22½ bushels to very nearly 27 bushels!

“In the next section of the table are given the results of plots 9. and 10., the former of

which had in the previous year been manured by superphosphate of lime and a small quantity of sulphate of ammonia, and the latter by superphosphate of lime and silicate of potash. To each of these plots $1\frac{1}{2}$ cwt. of sulphate and $1\frac{1}{2}$ cwt. of muriate of ammonia were now supplied. Upon plot 9. the whole of the manure was top-dressed, at once, early in the spring; but on plot 10. the salts were put on at four successive periods. The produce obtained by these salts of ammonia alone is 33 bushels and three-eighths, when sown all at once, and nearly 32 bushels when sown at four different times—quantities which amount to about 10 bushels per acre more than was obtained without manure. In the case of No. 9., indeed, the produce exceeds by $1\frac{1}{2}$ bushel that given by farm-yard manure, and in that of No. 10. it is all but identical with it. And if we take the weights of total corn, instead of the *measure* of the dressed corn, to which latter we chiefly refer, merely as a standard more conventionally understood, No. 10., by ammonia only, has given both more corn and more straw than the farm-yard manure, with all its minerals and carbonaceous substance.

“Let us see whether this almost specific effect of nitrogen, in restoring, for the reproduction of corn, a corn-exhausted soil, is borne out by the results of succeeding years.

“We should have omitted all reference to the results obtained with the wheat manure of Professor Liebig, had not the Professor, in the new edition of his ‘Letters,’ whilst fully admitting the failure of the manure—the composition of which, to use his own words when commenting upon it, ‘could be no secret, since every plant showed by its ashes the due proportion of the constituents essential to its growth’ (page 482),—not expressed any doubt as to the principle involved in such a manure, but, on the other hand, implied that the failure was due to a yet imperfect knowledge of the mechanical form and chemical qualities required to be given to the necessary constituents in order to fit them for their reception and nutritive action on the plant, rather than to any fallacy in the theory which would recommend to practical agriculture the supply by artificial means of the constituents of the ashes of plants as manures.

“The following table gives our selection of the results of the third season, 1846:—

TABLE III.—Harvest 1846. Selected Results.

| Description and Quantities of the Manures per Acre. | Dressed Corn per Acre, in Bushels in Pecks. | Total Corn per Acre, in lbs. | Straw per Acre, in lbs. |
|---|---|------------------------------|-------------------------|
| Section 1. | | | |
| Plot 3. No manure - - - - - | 17 $3\frac{1}{2}$ | 1207 | 1513 |
| “ 2. 14 tons of farm-yard manure - - | 27 $0\frac{1}{2}$ | 1826 | 2454 |
| Section 2. | | | |
| “ 10b. No manure - - - - - | 17 $2\frac{1}{2}$ | 1216 | 1455 |
| “ 10a. Sulphate of ammonia 224 lbs. - - | 27 $1\frac{1}{2}$ | 1850 | 2244 |
| Section 3. | | | |
| “ 5a ¹ . Ash of 3 loads of wheat straw - - | 19 $0\frac{1}{2}$ | — | 1541 |
| “ 5a ² . Ash of 3 loads of wheat straw, and top-dressed with 224 lbs. of sulphate of ammonia - - - - - | 27 0 | — | 2309 |
| Section 4. | | | |
| “ 6a. Liebig’s wheat manure 448 lbs. - - | 20 $1\frac{1}{2}$ | 1400 | 1676 |
| “ 6b. Liebig’s wheat manure 448 lbs., with 112 lbs. each of sulphate and muriate of ammonia - - - - - | 29 $0\frac{1}{2}$ | 1967 | 2571 |

“At this third experimental harvest we have on the continuously unmanured plot, namely, No. 3., not quite 18 bushels of dressed corn, as the normal produce of the season; and by its side we have on plot 10b—comprising one-half of the plot 10. of the previous years, and so highly manured by ammoniacal salts in 1845, but now unmanured,—rather more than $17\frac{1}{2}$ bushels. The near approach, again, to identity of result from the two unmanured plots, at once gives confidence in the accuracy of the experiments, and shows us how effectually the preceding crop had, in a practical point of view, reduced the plots, previously so differently circumstanced both as to manure and produce, to something like an uniform standard as regards

their grain-producing qualities. We take this opportunity of particularly calling attention to these coincidences in the amount of produce in the two unmanured plots of the different years, because it has been objected against our experiments, as already published, that confirmation was wanting as to the natural yield of soil and season.

"Plot 2. has, as before, 14 tons of farm-yard manure, and the produce is $27\frac{1}{2}$ bushels, or between 9 and 10 bushels more than without manure of any kind.

"On plot 10a, which in the previous year gave by ammoniacal salts alone a produce equal to that of the farm-yard manure, we have again a similar result: for 2 cwt. of sulphate of ammonia has now given 1850 lbs. of total corn, instead of 1826 lbs., which is the produce on plot 2. The straw of the latter is, however, slightly heavier than that by the ammoniacal salt.

"Again, plot 5a, which was in the previous season ~~unmanured~~, was now subdivided: on one half of it (namely, 5a¹) we have the ashes of wheat-straw alone, by which there is an increase of rather more than 1 bushel per acre of dressed corn; on the other half (or 5a²) we have, besides the straw ashes, 2 cwts. of sulphate of ammonia put on as a top-dressing: 2 cwts. of sulphate of ammonia have, in this case, only increased the produce beyond that of 5a¹ by $7\frac{1}{4}$ bushels of corn and 768 lbs. of straw, instead of by $9\frac{1}{2}$ bushels of corn and 789 lbs. of straw, which was the increase obtained by the same amount of ammoniacal salt on 10a, as compared with 10b. It will be observed, however, that in the former case the ammoniacal salts were top-dressed, but in the latter they were drilled at the time of sowing the seed; and it will be remembered that in 1845 the result was better as to corn on plot 9., where the salts were sown earlier, than on plot 10., where the top-dressing extended far into the spring. We have had several direct instances of this kind in our experience, and we would give it as a suggestion, in most cases applicable, that manures for wheat, and especially ammoniacal ones, should be applied before or at the time the seed is sown; for, although the apparent luxuriance of the crop is greater, and the produce of straw really heavier, by spring rather than autumn sowings of Peruvian guano and other ammoniacal manures, yet we believe that that of the corn will not be increased in an equivalent degree. Indeed, the success of the crop undoubtedly depends very materially on the progress of the underground growth during the winter months; and this again, other things being equal, upon the quantity of available nitrogenous constituents within the soil, without a liberal provision of which, the range of the fibrous feeders of the plant will not be such as to take up the minerals which the soil is competent to supply, and in such quantity as will be required during the after progress of the plant for its healthy and favourable growth.

"The next result to be noticed is that obtained on plot 6., now also divided into two equal portions, designated respectively 6a and 6b. Plot No. 6. had for the crop of 1844 superphosphate of lime and the phosphate of magnesia manure, and for that of 1845 superphosphate of lime, rape-cake, and ammoniacal salts. For this the third experimental season, it was devoted to the trial of the wheat manure manufactured under the sanction of Professor Liebig, and patented in this country.

"Upon plot 6a, 4 cwts. per acre of the patent wheat-manure were used, which gave $20\frac{1}{2}$ bushels, or rather more than 2 bushels beyond the produce of the unmanured plot; but as the manure contained, besides the minerals peculiar to it, some nitrogenous compounds, giving off a very perceptible odour of ammonia, some, at least, of the increase would be due to that substance. On plot 6b, however, the further addition of 1 cwt. each of sulphate and muriate of ammonia to this so-called "mineral manure," gives a produce of $29\frac{1}{2}$ bushels. In other words, the addition of ammoniacal salt to Liebig's mineral manure has increased the produce by very nearly 9 bushels per acre beyond that of the mineral manure alone, whilst the increase obtained over the unmanured plot, by 14 tons of farm-yard manure, was only $9\frac{1}{2}$ bushels.

"If, then, the 'mechanical form and chemical qualities' of the so-called 'mineral manure' were at fault, the sulphate of ammonia has, at least, compensated for the defect; and even supposing a mineral manure, founded on a knowledge of the composition of the ashes of the plant, be still the great desideratum, the farmer may rest contented, meanwhile, that he has in ammonia, supplied to him by Peruvian guano, by ammoniacal salts, and by other sources, so good a substitute.

"It surely is needless to attempt further to justify, by the results of individual years, our assertion, that in practical agriculture nitrogenous manures are peculiarly adapted to the growth of wheat. We shall therefore conclude this part of our subject by directing attention to the history of a few of the plots throughout the entire series of years, as compared with that of the unmanured plot during the same period.

In support of the view that leguminous plants do possess a superior power of reliance upon the atmosphere for their nitrogen, and, indeed, that it is to this property that they materially owe their efficacy in rotation with grain, we may refer to the admirable investigations into the chemistry of agriculture of M. Boussingault. His experiments, however, have not received the attention which they merit from the

agriculturists of this country; probably on account of the small amounts of produce which he obtained. But it must be remembered that his investigation had for its object to explain the practices of agriculture as he found them in his own locality, before attempting to deviate from its established rules. M. Boussingault states the rotation usually adopted at Bechelbronn, and throughout the greater part of Alsace, to be as follows:—

“Potatoes or beet-root;” “Wheat;” “Clover;” “Wheat;” and that the average of wheat so obtained is, after potatoes 19½ bushels, after beet-root 17 bushels, and after clover 24 bushels. Now we find by reference to his table that the first crop of wheat, grain, and straw removed 17 lbs. of phosphoric acid and 24 lbs. of potash and soda; the following clover crop, 18 lbs. of phosphoric acid and 77 lbs. potash and soda; and after this removal of alkalis and phosphates by the clover, a *larger* crop of wheat is obtained. Surely it would seem impossible to reconcile this result with a theory which supposes the produce of wheat to rise and fall with the quantity of minerals available within the soil. If, however, we admit that the first crop of wheat could not take up the mineral matters existing in the soil for want of nitrogenous supply, and that the clover crop, not being so dependent upon *supplied* nitrogen, was able to take up the minerals required for its growth, and that it moreover left in the soil sufficient ammonia, or its equivalent of nitrogen in some form, to give the *increased* crop of wheat, we have a much more consistent and probable solution of the results. There is little doubt that M. Boussingault could have increased his produce of wheat by means of ammoniacal salts; whether he could have done so economically is another question, depending of course upon the relative prices of grain and ammonia.

“The striking effect of phosphoric acid upon the growth of the turnip, indeed, is a fact so well known to every intelligent agriculturist in Great Britain, that it would seem quite superfluous to attempt to illustrate it by any direct experiments of our own. However, as Professor Liebig has again, in the recent edition of his ‘Letters,’ expressed an opinion entirely inconsistent with such a result, we will refer to one or two of the results obtained in our experimental turnip-field, which bear upon the opinion he has reiterated as follows:—thus, speaking of the exhaustion of phosphate of lime and alkaline phosphates by the sale of flour, cattle, &c., he says:—‘It is certain that this incessant removal of the phosphates must tend to exhaust the land and diminish its capability of producing grain. The fields of Great Britain are in a state of progressive exhaustion from this cause, as is proved by the rapid extension of the cultivation of turnips and mangold-wurzel, plants which contain the least amount of the phosphates, AND THEREFORE REQUIRE THE SMALLEST QUANTITY FOR THEIR DEVELOPMENT.’ Now we do not hesitate to say that, however small the quantity of phosphates contained in the turnip, the successful cultivation of it is more dependent upon a large supply of phosphoric acid in the manure than that of any other crop.

“In the following table, then, is given the amounts of bulb, since 1843, of—

First, the continuously unmanured plot;

Secondly, that with a large amount of the superphosphate of lime alone each year; and

Thirdly, that with a very liberal supply of potash with some soda and magnesia also, in addition to superphosphate of lime.

| Years. | Plot continuously Unmanured. | | | | Plot with Superphosphate of Lime alone every Year. | | | | Plot with Superphosphate of Lime and mixed Alkalis. | | | |
|---------|------------------------------|-------|------|------|--|-------|------|------|---|-------|------|------|
| | Tons. | cwts. | qrs. | lbs. | Tons. | cwts. | qrs. | lbs. | Tons. | cwts. | qrs. | lbs. |
| 1843 | 4 | 3 | 3 | 2 | 12 | 3 | 2 | 8 | 11 | 17 | 2 | 0 |
| 1844 | 2 | 4 | 1 | 0 | 7 | 14 | 3 | 0 | 5 | 13 | 2 | 0 |
| 1845 | 0 | 13 | 2 | 24 | 12 | 13 | 3 | 12 | 12 | 12 | 2 | 8 |
| 1846 | — | — | — | — | 1 | 18 | 0 | 0 | 3 | 10 | 1 | 20 |
| 1847 | — | — | — | — | 5 | 11 | 0 | 1 | 5 | 16 | 0 | 0 |
| 1848 | — | — | — | — | 10 | 11 | 0 | 8 | 9 | 14 | 2 | 0 |
| 1849 | — | — | — | — | 3 | 15 | 0 | 0 | 3 | 13 | 2 | 8 |
| 1850 | — | — | — | — | 11 | 9 | 0 | 0 | 9 | 7 | 1 | 12 |
| Totals. | — | — | — | — | 65 | 16 | 1 | 1 | 62 | 5 | 1 | 20 |
| Means. | — | — | — | — | 8 | 4 | 2 | 4 | 7 | 15 | 2 | 20 |

“It is seen then, that in the third season, viz. 1845, the produce of the unmanured plot is reduced to a few hundredweights, and since that period the size of the bulbs had been such that they have not been considered worth weighing. On the other hand, on the plot with *superphosphate of lime alone* for eight successive years, we have an average produce of about 8½ tons of bulb! varying, however, exceedingly, year by year, accord-

ing to the season. We see, too; that by the addition to superphosphate of lime of a large quantity of the alkalis, much greater than could be taken off in the crop, the average produce is not so great by nearly half a ton as by the superphosphate of lime alone. It must be admitted that this extraordinary effect of superphosphate of lime cannot be accounted for by the idea of merely supplying in it the actual constituents of the crop, but that it is due to some special agency in developing the assimilative processes of the plant. This opinion is favoured by the fact that in the case where the superphosphate of lime is at once neutralized by alkalis artificially supplied, the efficacy of the manure would seem to be thereby reduced. And from this again, we would gather that the effect of the phosphoric acid, as such, cannot be due merely to the liberation within the soil of its alkalis, or we should suppose that the artificial supply of these would at least have been attended with some increase of produce. But this is not the case, notwithstanding that by means of superphosphate of lime alone there has been taken from the land more of the alkalis in which the ash of the turnip so peculiarly abounds, than would have been lost from it in a century under the ordinary course of rotation and home manuring! Collateral experiments also clearly prove the importance of a liberal supply of organic substance rich in carbon — which always contains a considerable quantity of nitrogen also — if we would in practical agriculture increase the yield much beyond the amount which can be obtained by mineral manures alone; and these conditions being fulfilled, the direct supply of nitrogen, on the other hand, is by no means so generally essential. And it is where we have provided a liberal supply of constituents for organic formations, in addition to the mineral manures, that we have found the use of alkalis not to be without effect.

“But it is at any rate certain that phosphoric acid, though it forms so small a proportion of the ash of the turnip, has a very striking effect on its growth when applied as manure; and it is equally certain that the extended cultivation of root crops in Great Britain cannot be due to the deficiency of this substance for the growth of corn, and to the less dependence upon it of the root crops, as supposed by Baron Liebig.

“These curious and interesting facts in relation to the growth of turnips, as well as those which have been given in reference to wheat and to the leguminous crops, are sufficient to prove how impossible it is to form correct opinions on agricultural chemistry without the guidance of direct experiment in the field. And we are convinced that if Baron Liebig had watched the experiments which we have had in progress during the last eight years, he would long ago have arrived at conclusions in the main agreeing with those to which we have been irresistibly led: and we are disposed to believe that had he even seen the more detailed accounts of our results given in our own papers in this Journal, instead of the mere reference to them made by Mr. Pusey, he would rather have accepted them, as a step in an inquiry to which his own researches and writings had given such an impetus, than have designated them, as he has done, as entirely without value.

“So much, then, for the results of experiments in the field, and for the considerations in relation to the functional actions of plants, as bearing upon the character of the manure required for their growth in a course of practical agriculture. Let us now consider for a few moments what really are the main and characteristic features of practical agriculture, as most generally followed in this country.

“Let us suppose that the rotation adopted is that of Turnips, Barley, Clover, Wheat; that the turnips and clover are consumed upon the farm by stock, and that the meat thus produced, 40 bushels of barley and 30 bushels of wheat, are all the exports from the farm, the manure from the consumed turnips and clover, and the straw, both of barley and of wheat, being retained upon the farm. We have in this case, by the sale of grain, a loss of minerals to each acre of the farm of only 20 to 24 pounds of potass and soda, and 26 to 30 pounds of phosphoric acid, in the course of the rotation, or an average of 5 to 6 lbs. of potass and soda, and $6\frac{1}{2}$ to $7\frac{1}{2}$ lbs. of phosphoric acid per acre per annum. In the sale of the animals there would of course be an additional loss of phosphoric acid, though, especially if no breeding-stock were kept, this would be even much less considerable than in that of the grain; and the amount of the alkalis thus sent off the farm would, according to direct experiments of our own upon calves, bullocks, lambs, sheep, and pigs, probably be only about one-fourth that of the phosphoric acid. It has, however, long been decided in practical agriculture that phosphoric acid may be advantageously provided in the purchase of bones or other phosphatic manures, though in practice these are not found applicable as a direct manure for the wheat crop; and as we have already said, even when employed for the turnip, its efficacy is not to be accounted for merely as supplying a sufficiency of that substance to be stored up in the crop.

“In conclusion, then: if the theory of Baron Liebig simply implies that the growing plant must have within its reach a sufficiency of the mineral constituents of which it is to be built up, we fully and entirely assent to so evident a truism; but if, on the other hand, he would have it understood that it is of the mineral constituents, as would be collectively found in the ashes of the exported produce, that our soils are deficient relatively to other constituents, and that, in the present condition of agriculture in Great

Britain, 'we cannot increase the fertility of our fields by a supply of nitrogenized products, or by salts of ammonia alone, but rather that their produce increases or diminishes, in a direct ratio, with the supply of mineral elements capable of assimilation,' we do not hesitate to say that every fact with which we are acquainted, in relation to this point, is unfavourable to such a view. We have before stated, however, that if a cheap source of ammonia were at command, the available mineral constituents might in their turn become exhausted by its excessive use.

"NOTE. — This important paper so completely establishes what I wrote in our last Number on the entire failure of the mineral theory as a guide to the use of manures in practical farming, that I need only express my regret for the annoyance which its author has publicly expressed, as I am told, at those remarks. In cautioning the English farmer against what seemed to me a dangerous error, I certainly endeavoured to do justice to the real discoveries of Baron Liebig. Since the experiments, however, of Mr. Lawes and Dr. Gilbert have, as I hear, been disputed, I am bound to say that my confidence in the scrupulous accuracy of those gentlemen has been only strengthened by a subsequent visit to Rothamsted, in company with that eminent philosopher, Mons. Dumas. The extent of the experimental ground — the expenditure at which it has been kept up — the perseverance with which, year after year, it has been maintained, are such as might rather be expected from a public institution than a private landowner, and render Rothamsted, at present, the principal source of trustworthy scientific information on Agricultural Chemistry." — *Ph. Pusey.*

MANURE MANUFACTURE. The fecal matter so abundantly collected and dried in Paris, to form their dry portable manure, called *podrette*, is now mixed in its preparation with a small portion of a solution of sulphate of iron (*copperas*), whereby it loses its offensive smell, and may be evaporated without causing a nuisance to the neighbourhood. The ammonia, as well as the sulphuretted and phosphuretted hydrogen, which together concur to produce the nauseous effluvia, are at once condensed by this salt; the ammonia by its acid, and the gases by its oxide. When the putrid contents of a cesspool are mixed with a little copperas, they soon become nearly inodorous. This cheap metallic compound should be applied, under the administration of the police, to all the masses of putrefying dung which are deposited in the purlieus of London, and of the other large towns in the United Kingdom.

Estimated Quantities of Peruvian Guano.

| Sections. | Islands. | Deposits in Tons. | Tons. |
|-------------------------------------|------------------------|-------------------|------------|
| SOUTH ISLANDS | Chipana - - - | 280,609 | 7,621,407 |
| | Huanillos - - - | 1,612,505 | |
| | Punta de Lobos - - - | 1,460,790 | |
| | Peballon de Pica - - - | 2,975,050 | |
| | Puerto Ingles - - - | 1,292,510 | |
| CENTRE ISLANDS, OF CHINCHA ISLANDS. | North Island - - - | 7,600,000 | 18,250,000 |
| | Middle do. - - - | 6,450,000 | |
| | South do. - - - | 4,200,000 | |
| NORTH ISLANDS, OF LOBOS ISLANDS. | Lobos de Tierra - - - | 476,858 | 854,086 |
| | Lobos de Afuera - - - | 265,718 | |
| | Guanape - - - | 70,810 | |
| | Ferrol - - - | 30,700 | |

Twelve Islands, Total 27,024,493

The importations of Peruvian guano into Great Britain, according to the Parliamentary Returns, have been, —

| | | | |
|------|-------------|------|-------------|
| 1846 | 22,410 tons | 1849 | 78,567 tons |
| 1847 | 57,762 | 1850 | 95,083 |
| 1848 | 61,055 | 1851 | 199,732 |

showing an enormous progressive increase.

MARBLE. This title embraces such of the primitive, transition, and purer compact limestones of secondary formation, as may be quarried in solid blocks without fissures, and are susceptible of a fine polished surface. The finer the white, or more beautifully variegated the colours of the stone, the more valuable, *ceteris paribus*, is the marble. Its general characters are the following: —

Marble effervesces with acids; affords quicklime by calcination; has a conchoidal scaly fracture; is translucent only on the very edges; is easily scratched by the knife; has a spec. grav. of 2.7; admits of being sawn into slabs; and receives a brilliant polish. These qualities occur united in only three principal varieties of limestone; in the saccharoid limestone, so called from its fine granular texture resembling that of loaf sugar, and which constitutes modern statuary marble, like that of Carrara; 2. in the foliated limestone, consisting of a multitude of small facets formed of little plates applied to one another in every possible direction, constituting the antique statuary marble, like that of

Paros; 3. in many of the transition and carboniferous, or *encrinitic* limestones, subordinate to the coal formation.

The saccharoid and lamellar, or statuary marbles, belong entirely to primitive and transition districts. The greater part of the close-grained coloured marbles belong also to the same geological localities; and become so rare in the secondary limestone formations, that immense tracts of these occur without a single bed sufficiently entire and compact to constitute a workable marble. The limestone lying between the calcareo-siliceous sands and gritstone of the under oolite, and which is called Forest marble in England, being susceptible of a tolerable polish, and variegated with imbedded shells, has sometimes been worked into ornamental slabs in Oxfordshire, where it occurs in the neighbourhood of Whichwood forest; but this case can hardly be considered as an exception to the general rule. To constitute a profitable marble-quarry, there must be a large extent of homogeneous limestone, and a facility of transporting the blocks after they are dug. On examining these natural advantages of the beds of Carrara marble, we may readily understand how the statuary marbles discovered in the Pyrenees, Savoy, Corsica, &c. have never been able to come into competition with it in the market. In fact, the two sides of the valley of Carrara may be regarded as mountains of statuary marble of the finest quality.

Gypseous alabaster may be readily distinguished from marbles, because it does not effervesce with acids, and is soft enough to be scratched by the nail; stalagmitic alabaster is somewhat harder than marble, translucent, and variegated with regular stripes or undulations.

Some granular marbles are flexible in thin slabs, or, at least, become so by being dried at the fire; which shows, as Dolomieu suspected, that this property arises from a diminution of the attractive force among the particles, by the loss of the moisture.

The various tints of ornamental marbles generally proceed from oxides of iron; but the blue and green tints are sometimes caused by minute particles of hornblende, as in the slate-blue variety called Turchino, and in some green marbles of Germany. The black marbles are coloured by charcoal, mixed occasionally with sulphur and bitumen; when they constitute stinkstone.

Brard divides marbles, according to their localities, into classes, each of which contains eight subdivisions:—

1. Uni-coloured marbles; including only the white and the black.
2. Variegated marbles; those with irregular spots or veins.
3. Madreporic marbles, presenting animal remains in the shape of white or gray spots, with regularly disposed dots and stars in the centre.
4. Shell marbles; with only a few shells interspersed in the calcareous base.
5. Lumachella marbles, entirely composed of shells.
6. Cipolin marbles, containing veins of greenish talc.
7. Breccia marbles, formed of a number of angular fragments of different marbles, united by a common cement.

8. Puddingstone marbles; a conglomerate of rounded pieces.

Antique marbles.—The most remarkable of these are the following:—*Parian marble*, called *lychnites* by the ancients, because its quarries were worked by lamps; it has a yellowish-white colour; and a texture composed of fine shining scales, lying in all directions. The celebrated Arundelian tables at Oxford consist of Parian marble, as well as the Medicæan Venus. *Pentelic marble*, from Mount Pentetes, near Athens, resembles the Parian, but is somewhat denser and finer grained, with occasional greenish zones, produced by greenish talc, whence it is called by the Italians *Cipolino statuario*. The Parthenon, Propyleum, the Hippodrome, and other principal monuments of Athens, were of Pentelic marble; of which fine specimens may be seen among the Elgin collection, in the British Museum. *Marmo Greco*, or Greek white marble, is of a very lively snow white colour, rather harder than the preceding, and susceptible of a very fine polish. It was obtained from several islands of the Archipelago, as Scio, Samos, Lesbos, &c. *Translucent white marble*, *Marmo statuario* of the Italians, is very much like the Parian, only not so opaque. Columns and altars of this marble exist in Venice, and several towns of Lombardy; but the quarries are quite unknown. *Flexible white marble*, of which five or six tables are preserved in the house of Prince Borghese, at Rome. The *White marble of Lunz*, on the coast of Tuscan, was preferred by the Greek sculptors to both the Parian and Pentelic. *White marble of Carrara*, between Specia and Luoca, is of a fine white colour, but often traversed by gray veins, so that it is difficult to procure moderately large pieces free from them. It is not so apt to turn yellow as the Parian marble. This quarry was worked by the ancients, having been opened in the time of Julius Cæsar. Many antique statues remain of this marble. Its two principal quarries at the present day are those of Pianello and Polvazzo. In the centre of its block very limpid rock crystals are sometimes found, which are called Carrara diamonds. As the finest qualities are becoming excessively rare, it has risen

in price to about 3 guineas the cubic foot. The *White marble* of Mount Hymettus, in Greece, was not of a very pure white, but inclined a little to gray. The statue of Meleager, in the French Museum, is of this marble.

Black antique marble, the *Nero antico* of the Italians. This is more intensely black than any of our modern marbles; it is extremely scarce, occurring only in sculptured pieces. The *red antique marble*, *Egyptum* of the ancients, and *Rosso antico* of the Italians, is a beautiful marble of a deep blood-red colour, interspersed with white veins and with very minute white dots, as if strewn over with grains of sand. There is in the Grimani palace at Venice, a colossal statue of Marcus Agrippa in *rosso antico*, which was formerly preserved in the Pantheon at Rome. *Green antique marble*, *verde antico*, is a kind of breccia, whose paste is a mixture of talc and limestone, while the dark green fragments consist of serpentine. Very beautiful specimens of it are preserved at Parma. The best quality has a grass-green paste, with black spots of noble serpentine, but is never mingled with red spots. *Red spotted green antique marble*, has a dark green ground marked with small red and black spots, with fragments of *entrochi* changed into white marble. It is known only in small tablets. *Leek marble*; a rare variety of that colour of which there is a table in the Mint at Paris. *Marmo verde pagliocco* is of a yellowish green colour, and is found only in the ruins of ancient Rome. *Cervelas marble* of a deep red, with numerous gray and white veins, is said to be found in Africa, and highly esteemed in commerce. *Yellow antique marble*, *giallo antico* of the Italians; colour of the yolk of an egg, either uniform or marked with black or deep yellow rings. It is rare, but may be replaced by Sienna marble. *Red and white antique marbles*, found only among the ruins of ancient Rome. *Grand antique*, a breccia marble, containing shells, consists of large fragments of a black marble, traversed by veins or lines of a shining white. There are four columns of it in the Museum at Paris. *Antique Cipolino marble*. Cipolin is a name given to all such marbles as have greenish zones produced by green talc; their fracture is granular and shining, and displays here and there plates of talc. *Purple antique breccia marble*, is very variable in the colour and size of its spots. *Antique African breccia*, has a black ground, variegated with large fragments of a grayish-white, deep red, or purplish wine colour; and is one of the most beautiful marbles. *Rose-coloured antique breccia marble* is very scarce, occurring only in small tablets. There are various other kinds of ancient breccia, which it would be tedious to particularize.

Modern Marbles. — 1. British. Black marble is found at Ashford, Matlock, and Monsaldale in Derbyshire; black and white in the north part of Devonshire; the variegated marbles of Devonshire are generally reddish, brownish, and grayish, variously veined with white and yellow, or the colours are often intimately blended; the marbles from Torbay and Babbacombe, display a great variety in the mixture of their colours; the Plymouth marble is either ash-coloured with black veins, or blackish-gray and white, shaded with black veins; the cliffs near Marychurch exhibit marble quarries not only of great extent, but of superior beauty to any other in Devonshire, being either of a dove-coloured ground with reddish-purple and yellow veins, or of a black ground mottled with purplish globules. The green marble of Anglesea is not unlike the *verde antico*; its colours being greenish-black, leek-green, and sometimes dull purplish, irregularly blended with white. The white part is limestone, the green shades proceed from serpentine and asbestos. There are several fine varieties of marble in Derbyshire; the mottled gray in the neighbourhood of Moneyash, the light gray being rendered extremely beautiful by the number of purple veins which spread upon its polished surface in elegant irregular branches; but its chief ornament is the multitude of *entrochi*, with which this transition limestone-marble abounds. Much of the transition and carboniferous limestone of Wales and Westmoreland is capable of being worked up into agreeable dark marbles.

In Scotland, a particularly fine variety of white marble is found in immense beds, at Assynt in Sutherlandshire. A beautiful ash-gray marble of a very uniform grain, and susceptible of a fine polish, occurs on the north side of the ferry of Ballachulish in Invernesshire. One of the most beautiful varieties is that from the hill of Belepethrich in Tiree, one of the Hebrides. Its colours are pale blood-red, light flesh-red, and reddish-white, with dark green particles of hornblende, or rather sahite, diffused through the general base. The compact marble of Iona is of a fine grain, a dull white colour, somewhat resembling pure compact felspar. It is said by Bournon to consist of an intimate mixture of tremolite and carbonate of lime, sometimes with yellowish or greenish-yellow spots. The carboniferous limestone of many of the coal basins in the lowlands of Scotland may be worked into a tolerably good marble for chimney-pieces.

In Ireland, the Kilkenny marble is the one best known, having a black ground more or less varied with white marks produced by petrifications. The spar which occupies the place of the shells, sometimes assumes a greenish-yellow colour. An exceedingly fine black marble has also been raised at Crayleath in the county of Down. At Loughlougher, in the county of Tipperary, a fine purple marble is found, which when polished

looks very beautiful. The county of Kerry affords several variegated marbles, not unlike the Kilkenny.

France possesses a great many marble quarries which have been described by Brard, and of which a copious abstract is given under the article marble, — *Rees's Cyclopaedia*.

The territory of Genoa furnishes several beautiful varieties of marble, the most remarkable of which is the *polzevera di Genoa*, called in French the *vert d'Egypte* and *vert de mer*. It is a mixture of granular limestone with a talcose and serpentine substance disposed in veins; and it is sometimes mixed with a reddish body. This marble was formerly much employed in Italy, France, and England, for chimney-pieces, but its sombre appearance has put it out of fashion.

Corsica possesses a good statuary marble of a fine close grain, and pure milky whiteness, quarried at Ornofrio; it will bear comparison with that of Carrara; also a gray marble (*bardiglio*), a cipolin, and some other varieties. The island of Elba has immense quarries of a white marble with blackish-green veins.

Among the innumerable varieties of Italian marbles, the following deserve especial notice.

The *rovigio*, a white marble found at Padua; the white marble of St. Julien, at Pisa, of which the cathedral and celebrated slanting tower are built; the Biancone marble, white with a tinge of gray, quarried at Magurega for altars and tombs. Near Mergozza the white saline marble with gray veins is found, with which the cathedral of Milan is built. The black marble of Bergamo is called *paragone*, from its black colour, like touchstone; it has a pure intense tint, and is susceptible of a fine polish. The pure black marble of Como is also much esteemed. The *poleroso* of Pistoia is a black marble sprinkled with dots; and the beautiful white marble with black spots, from the Lago Maggiore, has been employed for decorating the interior of many churches in the Milanese. The Margorre marble found in several parts of the Milanese, is bluish veined with brown, and composes part of the dome of the cathedral of Milan. The green marble of Florence owes its colour to a copious admixture of steatite. Another green marble, called *verde di Prado*, occurs in Tuscany, near the little town of Prado. It is marked with spots of a deeper green than the rest, passing even into blackish-blue. The beautiful Sienna marble, or *brocattello di Siena*, has a yellow colour like the yolk of an egg, which is disposed in large irregular spots, surrounded with veins of bluish-red, passing sometimes into purple. At Montarenti, two leagues from Sienna, another yellow marble is met with, which is traversed by black and purplish-black veins. The Brema marble is yellow with white spots. The *mandelato* of the Italians is a light red marble with yellowish-white spots, found at Luggazzana, in the Veronese. The red marble of Verona is of a red rather inclining to yellow or hyacinth; a second variety of a dark red, composes the vast amphitheatre of Verona. Another marble is found near Verona, with large white spots in a reddish and greenish paste. Very fine columns have been made of it. The *occhio di pavone* is an Italian shell marble, in which the shells form large orbicular spots, red, white, and bluish. A madreporic marble known under the name of *pietra stellaria*, much employed in Italy, is entirely composed of star madrepores, converted into a gray and white substance, and is susceptible of an excellent polish. The village of Bretonico, in the Veronese, furnishes a splendid breccia marble, composed of yellow, steel-gray, and rose-coloured spots. That of Bergamo consists of black and gray fragments in a greenish cement. Florence marble, called also ruin and landscape marble, is an indurated calcareous marl.

Sicily abounds in marbles, the most valuable of which is that called by the English stone-cutters Sicilian jasper; it is red with large stripes like ribands, white, red, and sometimes green, which run zigzag with pretty acute angles.

Among the Genoese marbles we may notice the highly esteemed variety called *portor*, on account of the brilliant yellow veins in a deep black ground. The most beautiful kind comes from Porto-Venese, and Louis XIV. caused a great deal of it to be worked up for the decoration of Versailles. It costs now two pounds per cubic foot.

Of cutting and polishing marble. — The marble saw is a thin plate of soft iron, continually supplied during its sawing motion with water and the sharpest sand. The sawing of moderate pieces is performed by hand, but that of large slabs is most economically done by a proper mill.

The first substance used in the polishing process is the sharpest sand, which must be worked with till the surface becomes perfectly flat. Then a second, and even a third sand of increasing fineness is to be applied. The next substance is emery of progressive degrees of fineness, after which tripoli is employed; and the last polish is given with tin-putty. The body with which the sand is rubbed upon the marble, is usually a plate of iron; but for the subsequent process, a plate of lead is used with fine sand and emery. The polishing rubbers are coarse linen cloths, or bagging, wedged tight into an iron planing tool. In every step of the operation, a constant trickling supply of water is required.

Visitors of Derby may have an opportunity of inspecting Brown's extensive machinery for cutting marble into many ornamental forms, which has been well described in *Rees's Cyclopaedia*.

Sir James Jelf patented, in 1822, a combination of machinery for cutting any description of parallel mouldings upon marble slabs, for ornamental purposes; in which tools, supplied with sand and water, are made to traverse to and fro.

Mr. Tullock obtained a patent, in 1824, for improvements in machinery for sawing and grooving marble; the power being applied by means of toothed wheels bearing cranks, which gave the sea-saw motion to the cutting iron plates.

In November, 1829, Mr. Gibbs secured, by patent, an invention for working ornamental devices in marble, by means of a travelling drill, guided by a mould of wood, &c., in counter relief; and in April, 1833, Mr. G. W. Wilds obtained a patent for machinery, which consists of a series of circular cutters, for separating slabs from a block of marble; the block being advanced slowly to meet the cutters, by the progressive movement of a platform upon wheels, driven by the agency of a rack and pinion, as in the cylinder boring machine of the steam-engine manufacturer. Sand and water must be supplied, of course, from a hopper, to these smooth cutting discs of iron or copper. See GLASS-CUTTING. He proposes also to mould and polish marble, by applying a rotatory wheel or cylinder of any shape to it, in its carrying frame.

MARCASITE, is a variety of iron pyrites, containing generally a little arsenic.

MARGARATES, are saline compounds of margaric acid with the bases.

MARGARIC ACID, is one of the acid fats, produced by saponifying tallow with alkaline matter, and decomposing the soap with dilute acid. The term Margaric signifies PEARLY-looking.

The physical properties of the margaric and stearic acids are very similar; the chief difference is that the former is more fusible, melting at 140° F. The readiest mode of obtaining pure margaric acid, is to dissolve olive oil soap in water, to pour into the solution a solution of neutral acetate of lead, to wash and dry the precipitate, and then to remove its oleate of lead by ether, which does not affect its margarate of lead. The residuum being decomposed by boiling hot muriatic acid, affords margaric acid. When heated in a retort this acid boils. It is insoluble in water, very soluble in alcohol and ether; it reddens litmus paper, and decomposes, with the aid of heat, the carbonates of soda and potash.

MARGARIC ACID is obtained most easily by the distillation of stearic acid. The humidity at the beginning of the process must be expelled by a smart heat, otherwise explosive ebullitions are apt to occur. Whenever the ebullition becomes uniform, the fire is to be moderated.

MARINE ACID. See MURIATIC ACID and HYDROCHLORIC ACID.

MARINE SALT. See SALT.

MARL (*Marnes*, Fr.; *Mergel*, Germ.), is a mixed earthy substance, consisting of carbonate of lime, clay, and siliceous sand, in very variable proportions; it is sometimes compact, sometimes pulverulent. According to the predominance of one or other of these three main ingredients, marls may be distributed into calcareous, clayey, and sandy. See LIMESTONE.

MARQUETRY, is a peculiar kind of cabinet work, in which the surface of wood is ornamented with inlaid pieces of various colours and forms. The *marquetier* puts gold, silver, copper, tortoise-shell, mother-of-pearl, ivory, horn, &c. under contribution. These substances being reduced to laminae of proper thinness, are cut out into the desired forms by punches, which produce at once the full pattern or mould, and the empty one, which enclosed it; and both serve their separate purposes in marquetry. For the methods of dyeing the woods, &c., see IVORY.

MARTIAL, signifies belonging to iron; from Mars, the mythological name of this metal.

MASSICOT, is the yellow oxide of lead.

MASTIC (Eng. and Fr.; *Mastix*, Germ.), is a resin produced by making incisions in the *Pistacia Lentiscus*, a tree cultivated in the Levant, and chiefly in the island of Chios. It comes to us in yellow, brittle, transparent, rounded tears; which soften between the teeth; with bitterish taste and aromatic smell, and a specific gravity of 1.07. Mastic consists of two resins; one soluble in dilute alcohol; but both dissolve in strong alcohol. Its solution in spirit of wine constitutes a good varnish. It dissolves also in oil of turpentine. See VARNISH.

MATCHES, CHEMICAL. Put 40 grains of phosphorus into a wide-mouthed bottle. Add enough oil of turpentine to cover the phosphorus; then mix in 10 gra. of flower of sulphur. Put the bottle into hot water until the phosphorus is entirely dissolved; stop the mouth of the bottle with a cork, and well shake the whole until it has become cold; afterwards, pour off the supernatant oil of turpentine. Into the mixture of phosphorus which remains in the bottle dip the extremities of the matches, and, after some time, when they have become a little dried, dip them again into the following mixture:

Dissolve 30 grains of gum arabic in a small quantity of water; add to it 20 gra. of chlorate of potash, and mix them intimately together; then again add 10 gra. of soot previously mixed with a few drops of spirits of wine.

In about 12 hours the matches will be perfectly dry, when they will ignite on rubbing them over a rough surface.

MATCHES, INSTANTANEOUS LIGHT, without Sulphur and without Noise. Boetcher has published the following formula for the preparation of chemical matches, which ignite without noise:—

| | | | | | |
|--------------------|---|---|---|---|-----------|
| Take of Gum Arabic | - | - | - | - | 16 parts. |
| Phosphorus | - | - | - | - | 9 — |
| Nitrate of potash | - | - | - | - | 14 — |
| Manganese | - | - | - | - | 16 — |

Mix, so as to form a perfectly homogeneous mass.

More recently, this chemist, being desirous of making a mass equally good, but at a lower price, fixed on the following formula:—

| | | | | | |
|----------------------|---|---|---|---|----------|
| Take of Phosphorus | - | - | - | - | 4 parts. |
| Nitrate of potash | - | - | - | - | 10 — |
| Carpenters' glue | - | - | - | - | 6 — |
| Minium, or red ochre | - | - | - | - | 5 — |
| Smalt | - | - | - | - | 2 — |

The glue is cut and soaked in a little water for 24 hours; it is then put into a porcelain mortar, previously heated, so as to cause its liquefaction. The phosphorus is then added, afterwards the nitrate of potash, and lastly the minium and smalt, mixing the ingredients constantly with the pestle, until a perfectly homogeneous mixture is formed which may almost be drawn out in threads.

During this operation, the temperature must never be allowed to rise above 167° F., to prevent the inflammation of the particles of phosphorus.

This paste may be applied to wood prepared for the purpose, or to amadou previously dried for eight or twelve hours.

Paper matches may be made, which will afford an agreeable odour on igniting, by wetting slips of paper on both sides with tincture of benzoïn, and then applying a small quantity of the above composition to their extremities, by means of a small brush. On rubbing one of these on a rough surface, the mass inflames and ignites the paper without the intervention of a coating of sulphur.

Matches of wood may be made that will inflame without sulphur, by slightly carbonizing the ends of them, by placing them against a red hot plate of iron, and then dipping them into melted wax.

M. Diesel, of Ebersdorf, pupil of M. Wackenroder, has analyzed an excellent inflammable mass, and found the following proportions of ingredients in 100 parts:—

| | | | | | |
|-------------------|---|---|---|---|----|
| Phosphorus | - | - | - | - | 17 |
| Nitrate of potash | - | - | - | - | 38 |
| Minium | - | - | - | - | 24 |
| Glue | - | - | - | - | 21 |

MATCHES, LUCIFER. According to Dr. R. Boettger, in *Annalen der Chemie und Pharmacie*, vol. xlvii. p. 334., take

| | | | | | |
|------------------------|---|---|---|---|---------|
| Phosphorus | - | - | - | - | 4 parts |
| Nitre | - | - | - | - | 10 — |
| Fine glue | - | - | - | - | 6 — |
| Red ochre, or red lead | - | - | - | - | 5 — |
| Smalt | - | - | - | - | 2 — |

Convert the glue with a little water by a gentle heat into a smooth jelly, put it into a slightly warm porcelain mortar to liquefy; rub the phosphorus down through this gelatine at a temperature of about 140° or 150° Fahr.; add the nitre, then the red powder, and lastly the smalt, till the whole forms a uniform paste. To make writing-paper matches, which burn with a bright flame and diffuse an agreeable odour, moisten each side of the paper with tincture of benzoïn, dry it, cut it into slips, and smear one of their ends with a little of the above paste by means of a hair pencil. On rubbing the said end after it is dry against a rough surface the paper will take fire, without the intervention of sulphur.

To form lucifer wood matches, that act without sulphur, melt in a flat-bottomed, tin pan as much white wax as will stand one tenth of an inch deep; take a bundle of wooden matches free from resin, rub their ends against a red hot iron plate till the wood be slightly charred; dip them now in the melted wax for a moment, shake them well on taking them out, and finally dip them separately in the above viscid paste. When dry, they will kindle readily by friction.

For the rapid manufacture of the wooden splints for lucifer matches, a patent was granted to Mr. Reuben Partridge, in March, 1842. He employs a perforated metallic plate, having a steel face, strengthened by a bell metal back; see *figs. 887* & *888*. The size of the perforations must depend on that of the desired splints, but they must be as close together as possible, that there may be a very small blank space between them, otherwise the plate would afford too great resistance to the passage of the wood. By this construction, the whole area of the block of wood may be compressed laterally into the countersunk openings, and forced through the holes, which are slightly countersunk to favour the entrance and separation of the wooden fibres.

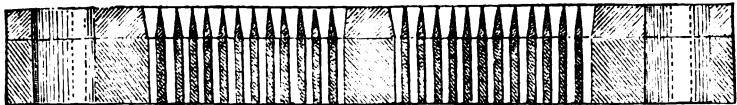
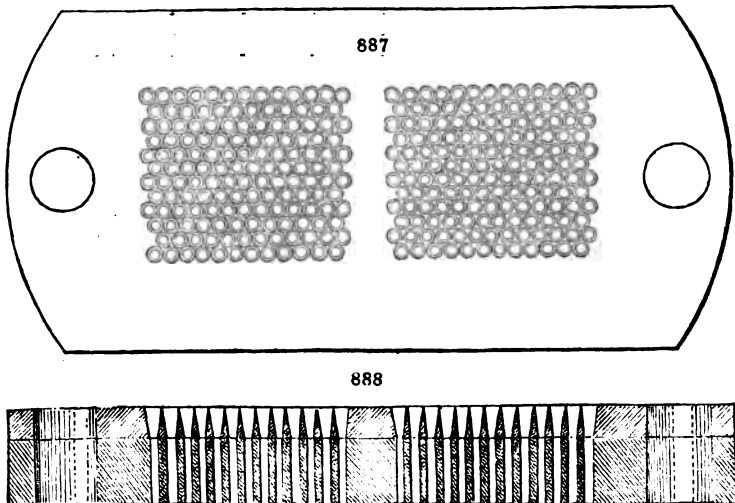


Fig. 887 represents the face of one of these plates; and *fig. 888* is a rectangular section through the plate. A convenient size of plate is three inches broad, six inches long, and one thick. The mode of pressing is by fixing the back of the plate against a firm resisting block or bearing, having an aperture equal to the area of the perforations in the plate, and then placing the end of the piece or pieces of wood in the direction of the grain against the face of the plate within the area of the perforated portion. A plunger or lever or other suitable mechanical agent being then applied to the back or reverse end of the piece of wood, it may be forced through the perforations in the plate, being first split as it advances by the cutting edges of the holes, and afterwards compressed and driven through the perforations in the plate, coming out on the opposite side or back of the plate in the form of a multitude of distinct splints, agreeably to the shapes and dimensions of the perforations. — *Newton's Journal*, C. S. vol. xxii. 268.

Manufacture of Lucifers. The first stage in the manufacture of lucifers is the cutting the wood, which is done, according to the extent of the manufactory, either by hand or by machinery. This, as well as the subsequent process of counting and placing the matches in frames, is in itself necessarily free from any inconvenience or evil consequences; nor does it appear that the third stage, which consists in melting the sulphur and dipping the heads of the matches in it, produces any inconvenience. The fourth, fifth, sixth, and seventh stages comprise the grinding, mulling, and mixing of the explosive compound; the process of dipping the matches in it, the counting and boxing. The dipping, counting, and packing, appear to be, according to Mr. Geist, the only departments in which the workpeople are in any way affected with peculiar complaints; we would even limit the appearance of the jaw disease to those engaged in dipping; at least all that we have examined on the subject were unanimous as to the fact that dippers only were attacked. There is a certain degree of secrecy observed relative to the proportions of the composition; and the mixture of the materials is generally performed by the proprietor of the manufactory, or by a confidential workman. Chlorate of potash is considered an essential ingredient in England; but in the manufactories at Nürnberg it has not been employed for a number of years, as its explosive properties much endangered the safety of the buildings and the limbs of the workmen.

The composition used in Nürnberg consists of one-third of phosphorus, of gum arabic (which is eschewed by English manufacturers on account of its hygrometric property), of water, and of colouring matter, for which either minium or Prussian blue

is employed. If ignition be required without a flame, the quantity of phosphorus is diminished, or nitrate of lead is added. The mixing is conducted in a water-bath; and during this process, and as long as the phosphorus is being ground or "mullered," copious fumes are evolved. The dipping is performed in the following manner:—The melted composition is spread upon a board covered with cloth or leather, and the workman dips the two ends of the matches alternately that are fixed in the frame; and as this is done with great rapidity, the disengagement of fumes is very considerable, and the more liable to be injurious, as they are evolved in a very concentrated form close to the face of the workmen. This department is generally left to a single workman; and the average number that he can dip in an hour, supposing each frame to hold 3,000 matches, would be 1,000,000.

After the matches have been dipped, they require to be dried. This is generally done in the room in which the former process is carried on; and as a temperature of from 80° to 90° Fahr. is necessary, the greatest quantity of fumes is evolved at this stage. When the matches are dried, the frames are removed from the drying room, and the lucifers are now ready to be counted out into boxes. As this is done with great rapidity, they frequently take fire, and, although instantly extinguished in the sawdust or the water which is at hand, the occurrence gives rise to an additional and frequent evolution of fumes.

MATRASS, is a bottle with a thin egg-shaped bottom, much used for digestions in chemical researches.

MATTE, is a crude black copper reduced, but not refined from sulphur and other heterogeneous substances.

MEADOW ORE, is conchoidal bog iron ore.

MEATS, PRESERVED. The interest which has of late attached to the subject of such meats, warrants us in bringing under examination the principles and practice on which this important branch of industry is based. The art itself is of modern invention, and differs in every respect from the old or common modes of preserving animal food. These, as is well known, depend on the use of culinary salt, saltpetre, sugar, or similar substances, which, when in solution, do not possess the power of absorbing oxygen gas, and therefore cut off effectually all access of air to the meat they protect. It might be imagined that water alone would answer this purpose; but the contrary is the case, for pure water absorbs oxygen, and is, therefore, all the less adapted for preserving meat, in proportion as it is free from saline matter, since it is then so much the more capable of combining with oxygen gas. Thus, snow, which is pure water crystallized, has a power of producing the panary fermentation when mixed with flour; and this it is able to do in consequence of the large quantity of gaseous oxygen which it contains. Similarly, rain water, and especially dew, will bring on the putrefaction of animal matters much sooner than spring water; and the vulgar prejudice respecting the effect of the moon's rays in accelerating the corruption of meat, is, beyond doubt, dependent upon the fact, that during clear moonlight nights, there is always a large deposition of dew; and this having fallen in a minutely divided state, possesses the largest amount of free oxygen, which pure or distilled water is capable of absorbing from the atmosphere, and, therefore, has a proportionate power of decomposing, — just as it also has of bleaching.

Thus far our remarks have been applied solely to raw or uncooked meats; but the practical bearing of the object which we have in hand really points to those which are, more or less, cooked or preserved. It is with reference to provisions of this kind, that a parliamentary enquiry is now in progress; and we cannot do better than show the great importance of such a subject to a maritime nation like Great Britain, by stating, that these provisions, when sound, are an absolute preventive of sea-scurvy, — a disease said, on good authority, to have destroyed more life, and to have done more damage to our navy, than all the enemies and tempests which that navy ever encountered. We need not go far in search of evidences to prove the fearful havoc caused by this disease; for we are well furnished by the history of Admiral Anson's memorable expedition, to damage the interests of Spain in the Pacific Ocean, by intercepting the annual treasure ship or galleon on her return to Europe. In spite of every thing that care and experience could do, Anson tells us that he lost, in all, fully four-fifths of his people by scurvy. Of 400 men, with whom the "Centurion" departed from England, only 200 lived to reach the island of Juan Fernandez, and no more than 8 of these were capable of doing duty; and but for a supply of others at St. Helena, there would not have been strength remaining to carry the ship to her anchorage. After describing, in the most pathetic manner, the dreadful sufferings of his crew, and rejoicing at the improvement caused by the sojourn at Juan Fernandez, the writer concludes, — "I therefore shall sum up the total of our loss since our departure from England, the better to convey some idea of our past sufferings and our present strength. We had buried on board the 'Centurion,' since leaving St. Helena, 292 men, and had remaining on board 214. This will, doubtless, appear a most extraordinary mortality; but yet, on board the 'Gloucester' (his other ship of war) it had been much greater: for, out of a much smaller crew than ours, they had buried the same number, and had only 82 remaining alive. It might," continues Anson, "have been

expected that, on board the 'Tryal' (a provision ship), the slaughter would have been most terrible; but it happened otherwise, for she escaped more favourably than the rest, since she *only* buried 43, and had now 39 remaining." The real object of the voyage was, however, not yet commenced; though out of 960 men, with which the three vessels left England, 626 were dead before this time.

It is almost superfluous to multiply instances of the same kind; though, in order to demonstrate the great utility of preserved meats in the navy, we shall give two or three other examples, as there is evidently a desire, in certain quarters, to get rid of a trifling labour and responsibility, by excluding this class of provisions altogether from our victualling departments. In October, 1788, the fleet of Admiral Keppell came into harbour, and, before the end of December, had sent 3,600 sick to the hospital at Haslar. In 1779, the channel fleet, under Sir C. Hardy, sent 2,500 to the hospital, and retained more than 1,000 on board for want of hospital accommodation. Within 4 months, during a subsequent year, 6,064 were sent to Haslar; and Sir R. Hawkins asserts, that, within the space of 20 years, to his own knowledge, not less than 10,000 men had died of scurvy. When Admiral Geary's fleet returned to Portsmouth, after a ten weeks' cruise in the Bay of Biscay, 2,400 men were ill of the scurvy; and the gross number of admissions into the hospital that year was 11,732, of whom 909 died. Now the highest medical authorities in this kingdom, and also on the continent, have all expressed the opinion that this fearful disease and mortality is altogether caused by the use of salt provisions; and the evidence of a host of navy surgeons and officers can be adduced to corroborate the truth of this view: therefore, not only motives of humanity, but also of self-interest, imperatively demand that, wherever unsalted provisions can be used, their employment should be insisted on, by the voice of the entire nation. Such being the case, it becomes necessary for us to inquire how far the art of preserving unsalted provisions has reached that degree of uniformity, and certainty of result, which alone can warrant their introduction into the navy.

The first successful attempt at the preservation of unsalted meats is of French origin, and due to the inventive skill of M. Appert. This gentleman, so long ago as the year 1810, received from the board of Arts and Manufactures of Paris the sum of 12,000 francs for his discovery of a mode of preserving animal and vegetable substances; the results of which had been then amply attested, by a prolonged experience in the French navy. Shortly after this period, Appert induced a Mr. Durant to visit London, for the purpose of taking out a patent; and this was accordingly done towards the end of the year 1811. In this patent, however, the claims were ridiculously wide, so much so, that the patent right was subsequently infringed with impunity. The claims included all kinds of fruit, meat, and vegetables, when subjected to the action of heat in closed vessels, more or less freed from air. As, however, the Society of Arts in London had presented in 1807, a premium to a Mr. J. Suddington, for "a method of preserving fruit without sugar for house or sea stores"—which method is exactly the same as that of M. Appert,—the validity of Durant's patent was at once called in question. Nevertheless, so satisfactory were the results, when applied to animal food, or mixed provisions, that the patent was eventually purchased from Durant by Messrs. Donkin, Hall and Gamble, for the sum of 1000*l.*; and the firm, thus established, became at once the sole manufacturers of preserved meats in this country. The process of Appert was, however, extremely defective in a manufacturing point of view. Nothing but glass bottles were to be used for containing the meats, and M. Appert remarks,—“I choose glass for this purpose, as being the most impenetrable to air, and have not ventured to make any experiment with a vessel made of any other substance.” Of course the fragility of this material, and the great difficulty of hermetically sealing the bottles with corks, threw an incalculable impediment in the way of the process as a commercial undertaking. Nor was it until after a long series of difficult and expensive experiments that Messrs. Donkin, Hall and Gamble, were able to overcome the primary difficulties of this invention, and produce provisions successfully preserved in tin plate vessels. Since that time but little alteration, and less improvement, has been made in the art, though its principles are far more complex than has hitherto been supposed.

From the researches of M. Gay Lussac, it appeared that the absence of oxygen was requisite to prevent fermentation; but it is now certain, that oxygen may be present with fermentable matters without producing any effect whatever. As there are substances and conditions which cause or accelerate fermentation, so there are others which prevent or retard it; and this is true, whatever be the nature of the fermentation. Although, therefore, the exclusion of oxygen be a means of preventing putrefaction, it is not the only means, nor is it, indeed, the easiest or simplest in application. The process of Appert certainly does not depend upon the exclusion of oxygen from the provisions he preserved, nor is this principle included in the improved process still practised, with such marked success, by the well known firm of Gamble, at Cork. We have had an opportunity of examining the air contained in perfectly sound canisters of Gamble's provisions, and have constantly found it to afford distinct evidences of the

presence of oxygen gas, even in cases several years old. The quantity is, indeed, much less than that in atmospheric air, but its existence is clear and undeniable. Hence we must look for some other theory than that which refers putrefaction to the presence of uncombined oxygen, if we wish to speculate upon the *modus operandi* of Gamble's method. Appert seems to have had a decided doubt as to the sufficiency of the oxygen theory, for he tells us that, "fire has a peculiar property, not only of changing the combination of the constituent parts of vegetable and animal productions, but also of retarding, for many years at least, if not of destroying altogether, the natural tendency of these same products to decomposition." And this opinion is confirmed from many startling facts, which cannot be reconciled to the supposition that oxygen is the sole or even principal agent of decomposition. Thus milk, which has been merely scalded, will keep much longer from the effect of this process, even though freely exposed to, or purposely impregnated with, oxygen gas. All kinds of meat exhibit a similar result. Again, very minute quantities of some mineral substances, as arsenic and corrosive sublimate, or of organic matters, such as creosote, naphtha, and the volatile oils, have the same action when applied to meat or vegetables; and, generally speaking, anything which will coagulate albumen has a preservative power upon organic substances. So that oxygen appears to exert a decomposing force only when one or other of the forms of soluble albumen is present. Now, the method of Appert, as improved by Gamble (for the firm of Donkin, Hall, and Gamble no longer exists), is to render the albumen of the meat or vegetable insoluble, and therefore scarcely, if at all, susceptible of the action of atmospheric oxygen. By this means the total exclusion of air from the tin cases is rendered unnecessary, for even if a small quantity of air remain in the case, it will exert no more influence than happens to a piece of coagulated albumen, or hard boiled white of egg, which, as is well known, may be exposed to the air for years without sensible alteration, though in its uncoagulated state it immediately putrefies. If, therefore, we were desired, in a few words, to express the essential characteristics of Gamble's process, it would not be by referring to the exclusion of air, but to the thorough coagulation of the albumen, that we should look for a satisfactory description. In this process, the meat, more or less cooked, is placed, with a quantity of gravy, in a tin vessel, capable of being hermetically sealed with solder; it is then heated, for some time, in a bath of muriate of lime, and the aperture neatly soldered up. After this it is again exposed to the action of the heated bath for a period, which varies with the size and nature of the contents of the vessels; and to prove that this latter operation is really the most important of the whole, it sometimes happens that cases which have begun to decompose are opened, resoldered, and again submitted to the muriate of lime bath, with the most perfect success, as regards the ultimate result. There is, however, no little difficulty in effecting the thorough coagulation of albumen by heat, when the quantity of albumen is small in proportion to the water present. A long continued and rather high temperature is then needed; more especially if vinegar or lactic acid be present in the fluid, as these tend to retain the albumen in solution: much must therefore depend upon practical experience; and it is not improbable that a heat in the bath but little higher than that of boiling water, would afford more uniform results, than would be obtained with a boiling saturated solution of muriate of lime. This subject will, however, be more fully discussed when speaking of Goldner's processes.

Although by no means free from occasional failures and certainly requiring improvement, the system of Gamble has in practice worked well; and provisions have been kept in this way, for a period of more than twenty-six years, without the slightest alteration in their particular qualities; and so well is this fact known and appreciated by British naval officers in general, that few vessels now leave our ports without at least a proper supply for cabin use. It was found by Sir John Ross that a number of those cases of these preserved provisions left for many years upon Fury beach and exposed to excessive variations of temperature, were, nevertheless, perfectly sound and wholesome as food when opened.

Guided, probably, by theoretical considerations, and too much impressed with the necessity of excluding oxygen, a Mr. Goldner, some few years ago, adopted the idea originally conceived by Sir Humphry Davy, of enclosing cooked provisions in a complete vacuum. For this purpose the provisions, slightly cooked on the surface, were enclosed in canisters, similar to those of Gamble, but stronger, and provided with a small opening in the cover. At this moment a slight condensation was effected by the application of a cold and damp rag or sponge, and simultaneously with this the small opening was soldered up. In theory, nothing could seem better adapted to insure success; but, from the late parliamentary disclosures, it is evident that the practical working of the invention affords anything but a satisfactory result. Nor is there much difficulty in conceiving how this may arise, as in the first place the application of a sudden heat to non-conducting materials, is almost certain to give rise to that peculiar condition of water called the spheroidal state, and by which the interior of the meat will be as

thoroughly protected from the effect of heat as if no heat were applied. Hence, even though steam in abundance may issue from the small opening in the cover, this is no proof that the meat in the centre of the vessel is even warmed; and still less does it warrant the supposition that the soluble albumen is thoroughly coagulated; and without which, as we have stated, preservation is scarcely possible. But, in addition to this, the application of a damp rag, in the way described, is, of all others, that by which a portion of air is most likely to be drawn into the vessel at the very moment when its total expulsion is taken for granted; and both these circumstances are more liable to happen with large than with small canisters. If, however, the meat has been but partially cooked, in consequence of the water in it assuming the spheroidal condition, and, at the same time, atmospheric oxygen is included, there can be no manner of doubt that putrefaction will occur, and run its course with the same rapidity as if no process whatever had been employed to prevent it. That water so situated in the substance of flesh is extremely prone to take on the form called spheroidal, needs no other proof than that the human hand may be deliberately passed through molten brass or iron with perfect impunity, and without even sensibly warming the fingers, as illustrated by M. Boutigny. It is not, therefore, enough to expose these canisters of provisions to heat, unless that heat be so gradually applied as to prevent the assumption of a spheroidal state by the watery portion of the food; and we cannot help thinking that much of the disappointment and loss, consequent upon this kind of manufacture, has its origin in a want of attention to the above circumstance. Where all power of circulation is prevented, as in the instance of these semi-solid meats, the tendency of the part in immediate contact with the source of heat to acquire a temperature capable of inducing the spheroidal condition, must be very great indeed; and hence, in speaking of the muriate of lime bath, employed by Gamble, we took occasion to hint, that more uniform results might perhaps be obtained by a moderate than by a high temperature. The probability is, that no advantage is gained by exceeding 220° Fahr.; and, viewing the subject chemically, even this seems too high, where time is less an object than perfection of manufacture.

It now remains only to offer a few remarks on the cooking of animal food, and its application to the wants of humanity. If flesh be digested for a short time in cold water or brine, it parts with several of its most important constituents, and therefore the practice of large and repeated washing is an unwise and foolishly fastidious operation. Cold water dissolves from meat its soluble phosphates, its lactic acid, its kreatine, and kreatinine, as well as its albumen. Without these constituents, however, the meat neither is nor can be fitted to supply the muscular wear and tear of the human frame. In fact, one of these substances (kreatine) has evidently a singular connection with muscular energy, as it exists in greatest quantity in the flesh of animals most remarkable for muscular power and activity. To exclude it, therefore, is to introduce an element of weakness in the dietary of our seamen, that cannot fail, in the long run, to show itself; and hence the enormous prostration of strength which accompanies the sea-scurvy; for it happens that, as kreatine is soluble in brine, but little of this valuable element remains in the contracted and solidified mass, known by the name of salt junk, and employed as food in the Navy, upon much the same principle as that ascribed to alligators, who swallow stones to appease the cravings of an empty stomach. If, however, there is an error in the commencement of our Navy victualling, there is still greater in the treatment of salt junk by its prejudiced and ill-informed consumers. Having had its albumen and other valuable matters removed by a cold solution of common salt, the junk is next deprived of its gelatine and osmazome, by the action of boiling water; and this gelatine, which, with the kreatine and lactic acid, would greatly facilitate the process of digestion, is thrown away as worthless; and nothing but a hard mass of fibrine, scarcely, if at all, susceptible of assimilation by the powers of the animal economy, remains to give the appearance of food to the product, and, as it were, keep the word of promise to the eye, "to break it to the hope." The following quotation from Liebig's *Researches on the Chemistry of Food*, may fitly occupy a place here. "It is obvious, that if flesh employed as food is again to become flesh in the body—if it is to retain the power of re-producing itself in its original condition—none of the constituents of raw flesh ought to be withdrawn from it during its preparation for food. If its consumption be altered in any way—if one of the constituents which belong essentially to its constitution be removed—a corresponding variation must take place in the power of that piece of flesh to reassume, in the living body, the original form and quality on which its properties in the living organism depend." It follows from this, that boiled flesh, when eaten *without* the soup formed in boiling it, is so much the *less* adapted for nutrition, the greater the quantity of water in which it has been boiled, and the longer the duration of the boiling.

Under such circumstances, we cannot wonder that in spite of the acknowledged purity of sea-water, disease to a large extent should prevail in our Navy, and that when any active malady makes its appearance, the mortality should greatly exceed that of the

army under similar circumstances. This is a more natural sequence of the system pursued with regard to provisions; and so far from abandoning altogether the employment of preserved meats from the casual putrefaction of a few cases, it seems to us that a wise government would rather seek to run all this inconvenience, by calling in the aid of science, than fall back into a supine condition, when the interest of the nation so loudly calls for activity. After all, however, we can find no proof that these preserved provisions have failed, except in the case of Goldner; for there are many other manufacturers, both in this country and in France, whose productions no more warrant the ban of exclusion, than a trifling accident deserves to be deemed a deliberate crime. If failure be a sufficient reason for interdicting further operations, how shall we account for the persevering assiduity of our dock-yard authorities in respect to ship-building? We sincerely hope that the parliamentary committee, now sitting, will not separate until the whole subject of preserved provisions has been fully and impartially investigated in all its details.

MEDALS. For their composition, see **Bronze** and **Copper**.

The Industrial Exhibition of 1851 has called into requisition, among others, the skilled labour of the medallist die-sinker. As a consequence, medals of all kinds and prices are being produced. A medal die is thus formed:—Steel of an uniform texture and kind being selected, it is forged, softened by annealing, and the face and cheek for the collar turned. The design approved of, the die-sinker proceeds to cut away those parts of the greatest depth by means of small chisels: the more minute details are taken out by gravers, chisel-edged, and gauged steel tools fitted into wood handles very short, and to fit the palm of the hand. As the work proceeds, proofs are taken in wax; when defective in form, the cutting is corrected, deficient in relief, it is sunk deeper. It will of course be borne in mind that, what will be relief in the medal, is intaglio in the dye. The inscription is introduced by means of small letter-punches. Then follows the hardening of the dye, a stage of the business the most critical, as a defect in the steel will at once be made apparent thereby, and the labour of months rendered useless in a few minutes. If the die endures this, it has only another test, viz., the making of a “hub,” or copy of the die in steel, and used for the correction of the duplicate copies of the die. The danger in this case arises from the want of uniformity of hardness. If irregular, one portion of the die must suffer, and become valueless.

Medal-making or stamping is thus carried on:—The press consists of a large and close threaded screw, to the top of which a large wheel is attached horizontally. The bed of the press is fitted with screws to secure the die in its place; when this is done the collar which gives the thickness of the medal is fitted on, the die forming the reverse of the medal is attached to the screw; a blank (a piece of metal cut out to form the medal) is then introduced. Motion is imparted to the wheel, which operates on the screw; a blow is given, and if the impression is soft and shallow, a medal is produced; but if deep, repeated blows are given to bring the impression up. When bronze or silver is the material in which the medal is to be produced, as many as 20 or even 30 blows are necessary. The medal is then taken out of the press, the edge turned, and the operation is complete.

By collar die, is meant that portion which gives the thickness to the medal or coin to be struck. All medal dies are of three parts, viz., the reverse, obverse, and collar. The smaller class of dies are cut in steel entirely, the larger kinds for brass foundry and other purposes are “laid” or covered with steel on a foundation of iron. When indentations occur, the die is what is called “fullered,” or hollowed, and the steel follows the same in a parallel thickness.

MEERSCHAUM (Germ.; *sea-froth*, Eng.; *Ecume de Mer*, *Magnésie carbonatée silicifère*, Fr.), is a white mineral, of a somewhat earthy appearance, always soft, but dry to the touch, and adhering to the tongue. Specific gravity, 2·6 to 3·4; affords water by calcination; fuses with difficulty at the blowpipe into a white enamel; and is acted upon by acids. It consists, according to Klaproth, of silica, 41·5; magnesia, 18·25; water and carbonic acid, 39. Other analysts give, silica 50, magnesia 25, water 25. It occurs in veins or kidney-shaped nodules, among rocks of serpentine, at Egribos, in the island of Negropont, Eski-Schehir in Anatolia, Brussa at the foot of Mount Olympus, at Baldissero in Piedmont, in the serpentine veins of Cornwall, &c.

When first dug up, it is soft, greasy, and lathers like soap; and is on that account used by the Tartars in washing their linen. The well-known Turkey tobacco-pipes are made from it, by a process analogous to that for making pottery ware. The bowls of the pipes, when imported into Germany, are prepared for sale by soaking them first in tallow, then in wax, and finally by polishing them with shave-grass.

MELLITE, (Eng. and Fr.; *Honigstein*, Germ.) See **HONIGSTEIN**.

MELLITIC ACID, which is associated with alumina in the preceding mineral, crystallizes in small colourless needles, is without smell, of a strongly acid taste, permanent in the air, soluble in water and alcohol, as also in boiling hot concentrated sulphuric acid, but is decomposed by hot nitric acid, and consists of 50·21 carbon, and

49·79 oxygen. It is carbonized at a red heat, without the production of any inflammable oil.

MELLON, is a new compound of carbon and azote, discovered by M. Liebig, by heating bi-sulpho-cyanide of mercury. The mellon remains at the bottom of the retort under the form of a yellow powder.

MENACHIANITE, an ore of titanium, found in the bed of a rivulet which flows into the valley Menacan, in Cornwall.

MERCURY or QUICKSILVER. This metal is distinguished by its fluidity at common temperatures; its density = 13·6; its silver blue lustre; and its extreme mobility. A cold of 39° below zero of Fahrenheit, or -40° cent., is required for its congelation, in which state its density is increased in the proportion of 10 to 9, or it becomes of spec. grav. 15·0. At a temperature of 656° F. it boils and distils off in an elastic vapour; which, being condensed by cold, forms purified mercury.

Mercury combines with great readiness with certain metals, as gold, silver, zinc, tin, and bismuth, forming, in certain proportions, fluid solutions of these metals. Such mercurial alloys are called *amalgams*. This property is extensively employed in many arts; as in extracting gold and silver from their ores; in gilding, plating, making looking-glasses, &c. Humboldt estimates at 16,000 quintals, of 100 lbs. each, the quantity of mercury annually employed at his visit to America, in the treatment of the mines of New Spain; three-fourths of which came from European mines.

The mercurial ores may be divided into four species:—

1. *Native quicksilver*.—It occurs in most of the mines of the other mercurial ores, in the form of small drops attached to the rocks, or lodged in the crevices of other ores.

2. *Argentiferous mercury, or native silver amalgam*.—It has a silver-white colour, and is more or less soft, according to the proportion which the mercury bears to the silver. Its density is sometimes so high as 14. A moderate heat dissipates the mercury, and leaves the silver. Klaproth states its constituents at silver 36, and mercury 64, in 100; but Cordier makes them to be, 27½ silver, and 72½ mercury. It occurs crystallized in a variety of forms. It has been found in the territory of Deux-Ponts, at Rozensau and Niderstana, in Hungary, in a canton of Tyrol, at Sahlberg in Sweden, at Kolyvan in Siberia, and at Allemont in Dauphiny; in small quantity at Almaden in Spain, and at Idria in Carniola. By the chemical union of the mercury with the silver, the amalgam, which should by calculation have a spec. grav. of only 12·5, acquires that of 14·11, according to M. Cordier.

3. *Sulphuret of mercury*, commonly called Cinnabar, is a red mineral of various shades; burning at the blowpipe with a blue flame, volatilizing entirely with the smell of burning sulphur, and giving a quicksilver coating to a plate of copper held in the fumes. Even the powder of cinnabar rubbed on copper whitens it. Its density varies from 6·9 to 10·2. It becomes negatively electrical by friction. Analysed by Klaproth, it was found to consist of mercury 84·5, sulphur 14·75. Its composition, viewed as a bisulphuret of mercury, is, mercury 86·2, sulphur 13·8. The finest crystals of sulphuret of mercury come from China, and Almaden in Spain. These contain, according to Klaproth, 85 per cent. of mercury.

A *bituminous sulphuret of mercury* appears to be the base of the great exploration of Idria; it is of a dark liver-red hue; and of a slaty texture, with straight or twisted plates. It exists in large masses in the bituminous schists of Idria. M. Beurard mentions also the locality of Munster-Appel, in the duchy of Deux-Ponts, where the ore includes impressions of fishes, curiously spotted with cinnabar.

The compact variety of the Idria ore seems very complex in composition, according to the following analysis of Klaproth:—Mercury, 81·8; sulphur, 13·75; carbon, 2·3; silica, 0·65; alumina, 0·55; oxide of iron, 0·20; copper, 0·02; water, 0·73; in 100 parts. M. Beurard mentions another variety from the Palatinate, which yields a large quantity of bitumen by distillation; and it was present in all the specimens of these ores analyzed by me for the German Mines Company. At Idria and Almaden the sulphurets are extremely rich in mercury.

4. *Muriated mercury, or the Chloride of mercury*, commonly called Horn mercury. This ore occurs in very small crystals of a pearl-gray or greenish-gray colour, or in small nipples which stud, like crystals, the cavities, fissures, or geodes among the ferruginous gangues of the other ores of mercury. It is brittle, and entirely volatile at the blowpipe, characters which distinguish it from horn silver.

The geological position of the mercurial ores, in all parts of the world, is in the strata which commence the series of secondary formations. Sometimes they are found in the red sandstone above the coal, as at Menildot, in the old duchy of Deux-Ponts, at Durasno in Mexico, at Cuença in New Granada, at Cerros de Gauzan and Upar in Peru; in the subordinate porphyries, as at Deux-Ponts, San Juan de la Chica in Peru, and at Cerro-del-Fraile, near the town of San-Felipe; they occur also among the strata below, or subordinate to the calcareous formation, called *schists*, in Germany, or

among the accompanying bituminous schists, as at Idria in Carniola; and, lastly, they form masses in the zechstein itself. Thus, it appears that the mercurial deposits are confined within very narrow geological limits, between the calcareous beds of zechstein, and the red sandstone. They occur at times in carbonaceous nodules, derived from the decomposition of mosses of various kinds; and the whole mercurial deposit is occasionally covered with beds of charcoal, as at Durasno.

They are even sometimes accompanied with the remains of organic bodies, such as casts of fishes, fossil shells, silicified wood, and true coal. The last fact has been observed at Potzberg, in the works of Drey-Koenigszug, by M. Brongniart. These sandstones, bituminous schists, and indurated clays, contain mercury both in the state of sulphuret and in the native form. They are more or less penetrated with the ore, forming sometimes numerous beds of very great thickness; while, in the more antient or the primitive formations, these ores exist only in very small quantity associated with tin. Mercury is, generally speaking, a metal sparingly distributed in nature, and its mines are very rare.

The great exploitations of Idria in Friuli, in the county of Goritz, were discovered in 1497, and the principal ore mined there is the bituminous sulphuret. The workings of this mine have been pushed to the depth of 280 yards. The product in quicksilver might easily amount annually to 6000 metric quintals = 600 tons British; but, in order to uphold the price of the metal, the Austrian government has restricted the production to 150 tons. The memorable fire of 1803 was most disastrous to these mines. It was extinguished only by drowning all the underground workings. The sublimed mercury in this catastrophe occasioned diseases and nervous tremblings to more than 900 persons in the neighbourhood.

Pliny has recorded two interesting facts: 1. that the Greeks imported red cinnabar from Almaden 700 years before the Christian era; and 2. that Rome, in his time, annually received 700,000 pounds from the same mines. Since 1827, they have produced 22,000 cwts. of mercury every year, with a corps of 700 miners and 200 smelters; and, indeed, the veins are so extremely rich, that though they have been worked pretty constantly during so many centuries, the mines have hardly reached the depth of 330 yards, or something less than 1000 feet. The lode actually under exploration is from 14 to 16 yards thick, and it becomes thicker still at the crossing of the veins. The totality of the ore is extracted. It yields in their smelting works only 10 per cent. upon an average, but there is no doubt, from the analysis of the ores, that nearly one half of the quicksilver is lost, and dispersed in the air, to the great injury of the workmen's health, in consequence of the barbarous apparatus of aludels employed in its sublimation; an apparatus which has remained without any material change for the better since the days of the Moorish dominion in Spain. M. Le Play, the eminent *Ingenieur des Mines*, who published, in a recent volume of the *Annales des Mines*, his *Itinéraire* to Almaden, says, that the mercurial contents of the ores are *notablement plus élevées* than the product.

These veins extend all the way from the town of Chillon to Almadenejos. Upon the borders of the streamlet Balde Azogues, a black slate is also mined which is abundantly impregnated with metallic mercury. The ores are treated in 13 double furnaces, which I shall presently describe. "Le mercure," says M. Le Play, "a sur la santé des ouvriers la plus funeste influence, et l'on ne peut se défendre d'un sentiment pénible en voyant l'empressement avec lequel des jeunes gens, pleins de force et de santé, se disputent la faveur d'aller chercher dans les mines, des maladies cruelles, et souvent une mort prématurée. La population des mineurs d'Almaden méritent le plus haut intérêt." These victims of a deplorable mismanagement are described as being a laborious, simple-minded, virtuous race of beings, who are thus condemned to breathe an atmosphere impregnated far and near with the fumes of a volatile poison, which the lessons of science, as I shall presently demonstrate, might readily repress, with the effect of not only protecting the health of the population, but of vastly augmenting the revenues of the state.

These celebrated mines, near to which lie those of *Las Cuebas* and of *Almadenejos*, were known to the Romans. After having been the property of the religious knights of *Calatrava*, who had assisted in expelling the Moors, they were farmed off to the celebrated *Fugger* merchants of Augsburg; and afterwards explored on account of the government, from the date of 1645 till the present time. Their produce was, till very lately, entirely appropriated to the treatment of the gold and silver ores of the new world.

The mines of the *Palatinate*, situated on the left bank of the Rhine, though they do not approach in richness and importance to those of Idria and Almaden, merit, however, all the attention of the government that farms them out. They are numerous, and varied in geological position. Those of Drey-Koenigszug, at Potzberg, near Kussel, deserve particular notice. The workings have reached a depth of more than 220 yards; the ore being a sandstone strongly impregnated with sulphuret of mercury. The produce of these mines is estimated at about 30 tons per annum.

There are also in Hungary, Bohemia, and several other parts of Germany, some inconsiderable exploitations of mercury, the total produce of which is valued at about 30 or 40 tons on an average of several years.

The mines of Guancavelica, in Peru, are the more interesting, as their products are directly employed in treating the ores of gold and silver, which abound in that portion of America. These quicksilver mines, explored since 1570, produced, up to 1800, 53,700 tons of that metal; but the actual produce of the explorations of these countries was, according to Helms, about the beginning of this century, from 170 to 180 tons per annum.

In 1782 recourse was had by the South American miners to the mercury extracted in the province of Yun-nan, in China.

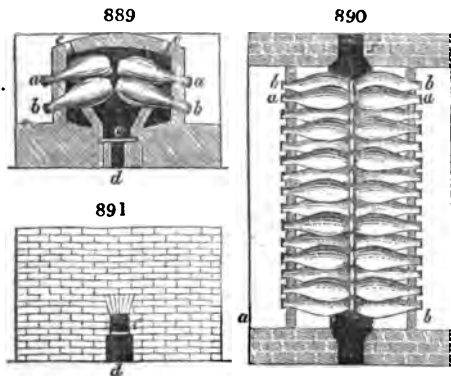
The metallurgic treatment of the quicksilver ores is tolerably simple. In general, when the sulphuret of mercury, the most common ore, has been pulverized, and sometimes washed, it is introduced into retorts of cast iron, sheet iron, or even stoneware, in mixture with an equal weight of quicklime. These retorts are arranged in various ways.

Prior to the 17th century, the method called *per descensum* was the only one in use for distilling mercury; and it was effected by means of two earthen pots adjusted over each other. The upper pot, filled with ore, and closed at the top, was covered over with burning fuel; and the mercurial vapours expelled by the heat, passed down through small holes in the bottom of the pot, to be condensed in another vessel placed below. However convenient this apparatus might be, on account of the facility of transporting it, wherever the ore was found, its inefficiency and the losses it occasioned were eventually recognized. Hence, before 1635, some smelting works of the Palatinate had given up the method *per descensum*, which was, however, still retained in Idria; and they substituted for it the furnaces called *galleries*. At first earthenware retorts were employed in these furnaces; but they were soon succeeded by iron retorts. In the Palatinate this mode of operating is still in use. At Idria, in the year 1750, a great distillatory apparatus was established for the treatment of the mercurial ores, in imitation of those which previously existed at Almaden, in Spain, and called *aludel-furnaces*. But, since 1794, these aludels have been suppressed, and new distillatory apparatus have been constructed at Idria, remarkable only for their magnitude; exceeding, in this respect, every other metallurgic erection.

There exist, therefore, three kinds of apparatus for the distillation of mercury: 1. the furnace called a *gallery*; 2. the furnace with *aludels*; and 3. the *large apparatus* of Idria. I shall describe each of these briefly, in succession.

1. *Furnace called Gallery of the Palatinate.*—The construction of this furnace is disposed so as to contain four ranges, *a a', b b'*, of large retorts, styled cucurbits, of cast iron, in which the ore of mercury is subjected to distillation. This arrangement is shewn in *fig. 889.*, which presents a vertical section in the line *a b* of the ground plan, *fig. 890.* In the ground plan, the roof *e e'* of the furnace (*fig. 889.*) is supposed to be lifted off, in order to shew the disposition of the four ranges of cucurbits upon the grate *c f*, *figs. 889, 890.*, which receives the pit-coal employed as fuel. Under this grate extends an ash-pit *d*. *Fig. 891.*, which exhibits an elevation of the furnace, points out this ash-pit, as well as one of the two doors *c*, by which the fuel is thrown upon the grate

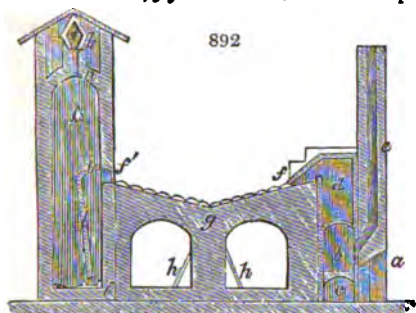
c f. Openings *e e'*, (*fig. 889.*) are left over the top arch of the furnace, whereby the draught of air may receive a suitable direction. The grate of the fire-place extends over the whole length of the furnace, *fig. 890.*, from the door *c* to the door *f*, situated at the opposite extremity. The furnace called *gallery* includes commonly 30 cucurbits, and in some establishments even 52. Into each are introduced from 56 to 70 pounds of ore, and 15 to 18 pounds of quicklime, a mixture which fills no more than two-thirds of the cucurbit; to the neck a stoneware receiver is adapted, containing water to half



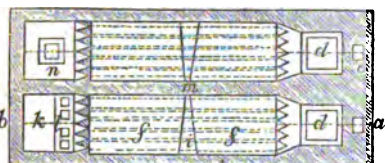
its height. The fire, at first moderate, is eventually pushed till the cucurbits are red hot. The operation being concluded, the contents of the receivers are poured out into a wooden bowl placed upon a plank above a bucket; the quicksilver falls to the bottom

of the bowl, and the water draws over the *black mercury*, for so the substance that coats the inside of the receivers is called. This is considered to be a mixture of sulphuret and oxide of mercury. The *black mercury*, taken out of the tub and dried, is distilled anew with excess of lime; after which the residuum in the retorts is thrown away, as useless.

Aludel furnaces of Almaden. — *Figs. 892.* and *893.* represent the great furnaces with aludels in use at Almaden, and anciently in Idria; for between the two establishments there was in fact little difference before the year 1794. *Figs. 892.* and *895.* present two vertical sections; *Figs. 893.* and *894.* are two plans of two similar furnaces, conjoined in one body of brickwork. In the four figures the following objects are to be remarked; a door *a*, by which the wood is introduced into the fire-place *b*. This is perforated with holes for the passage of air; the ash-pit *c*, is seen beneath. An upper chamber *d*, contains the mercurial ores distributed upon open arches, which form the perforated sole of this chamber. Immediately over these arches, there are piled up in a dome form, large blocks of a limestone, very poor in quicksilver ore; above these are laid blocks of a smaller size, then ores of rather inferior quality, and stamped ores mixed with richer minerals. Lastly, the whole is covered up with soft bricks, formed of clay kneaded with *schlich*, and with small pieces of sulphuret of mercury. Six ranges of aludels or stoneware tubes *ff*, of a pear shape, luted together with clay, are mounted in front of each of the two furnaces, on a double sloping terrace, having in its lowest middle line two

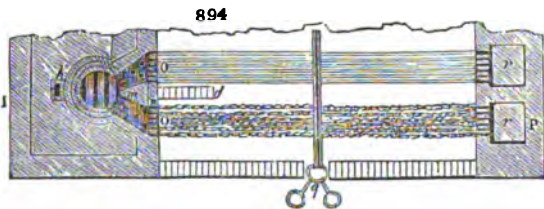


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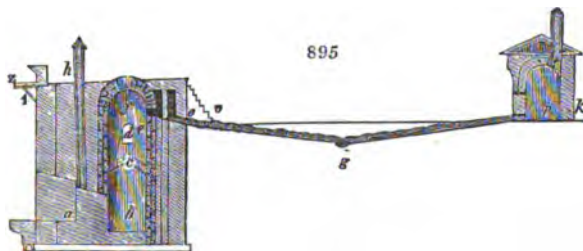
893

gutters *t v*, a little inclined towards the intermediate wall *m*. In each range the aludel placed at the line *t m v* of *fig. 893.*, that is to say at the lowest point, *g*, *figs. 892. 895.*, is



894

pierced with a hole. Thereby the mercury which had been volatilized in *d*, if it be already condensed by the cooling in the series of aludels *fg*, may pass into the corres-



895

ponding gutter, next into the hole *m*, *fig. 893.*, and after that into the wooden pipes *h h'*, *fig. 892.*, which conduct it across the masonry of the terrace into cisterns filled with water; see *g*, *fig. 894.*, which is the plan of *fig. 895.*

The portion of mercury not condensed in the range of aludels, *fg*, which is the most

considerable, goes in the state of vapour, into a chamber *k*; but in passing under a partition *ll*, a certain portion is deposited in a cistern *i*, filled with water. The greater part of the vapours diffused in the chamber *k* is thereby condensed, and the mercury falls down upon the two inclined planes which form its bottom. What may still exist as vapour passes into an upper chamber *k'*, by a small chimney *n*. On one of the sides of this chamber there is a shutter which may be opened at pleasure from below upwards, and beneath this shutter, there is a gutter into which a notable quantity of mercury collects. Much of it is also found condensed in the aludels. These facts prove that this process has inconveniences, which have been tried to be remedied by the more extensive but rather unchemical grand apparatus of Idria.

Details of the aludel apparatus: 25 are set in each of the 12 ranges, seen in *fig. 894*. constituting 300 pear-shaped stoneware vessels, open at both ends, being merely thrust into one another, and luted with loam. What a multitude of joints, of which a great many must be continually giving way by the shrinkage of the luting, whereby the mercurial fumes will escape with great loss of product, to poison the air!

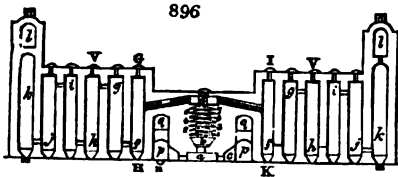
a, is the door of the fire-place; *c*, the perforated arches upon which the ore is piled in the chamber *e*, through the door *d*, and an orifice at top; the latter being closed during the distillation; *ff* are vents for conducting the mercurial vapours into two chambers *i*, separated by a triangular body of masonry *m n*; *h* is the smoke chimney of the fire-place; *o o*, are the ranges of aludels, in connection with the chamber *i*, which are laid slantingly towards the gutter *q*, upon the double inclined plane terrace, and terminate in the chamber *h q*; this being surmounted by two chimneys *t*. The mercury is collected in these aludels and in the basins at *q* and *p*, *fig. 894*. *r* is a thin stone partition set up between the two principal walls of each of the furnaces. *v* is the stair of the aludel terrace, leading to the platform which surmounts the furnace; *z* is a gutter for conducting away the rains which may fall upon the buildings.

Great apparatus of Idria. — Before entering into details of this laboratory, it will not be useless to recapitulate the metallurgic classification of the ores treated in it. 1. The ores in large blocks, fragments, or shivers, whose size varies from a cubic foot to that of a nut. 2. The smaller ores, from the size of a nut to that of grains of dust.

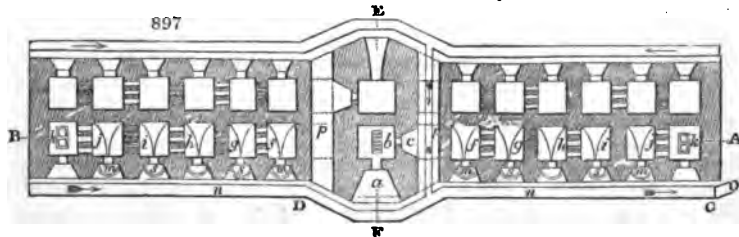
The first class of large ores comprises three subdivisions, namely; *a*, blocks of metaliferous rocks, which is the most abundant and the poorest species of ore, affording only one per cent. of mercury; *b*, the massive sulphuret of mercury, the richest and rarest ore, yielding 80 per cent. when it is picked; *c*, the fragments or splinters proceeding from the breaking and sorting, and which vary in value, from 1 to 40 per cent.

The second class of small ores comprises: *d*, the fragments or shivers extracted from the mine in the state of little pieces, affording from 10 to 12 per cent.; *e*, the kernels of ore, separated on the sieve, yielding 32 per cent.; *f*, the sands and paste called *schlich*, obtained in the treatment of the poorest ores, by means of the stamps and washing tables; 100 parts of this *schlich* give at least 8 of quicksilver.

The general aspect of the apparatus is indicated by *figs. 896, 897, and 898*. *Fig. 898*.



represents the exterior, but only one half, which is enough, as it resembles exactly the other, which is not shown. In these three figures the following objects may be distinguished; *figs. 896, 897*., *a*, door of the fire-place; *b*, the furnace in which beech-wood is burned mixed with a little fir-wood; *c*, door of the ash-pit, extended beneath; *d*, a space in which the ores are deposited upon the seven arches, 1. to 7., as indicated in *figs. 896. and 899.*; *e e*, brick tunnels, by which the smoke of the fuel and the vapours of mercury pass, on the one side, into successive chambers *f k*.



fg h i j k l are passages which permit the circulation of the vapours from the furnace *a b c d*, to the chimneys *ll*. *Figs. 896. and 897.* exhibit clearly the distribution of these

openings on each side of the same furnace, and in each half of the apparatus, which is double, as *fig. 897.* shows; the spaces without letters being in every respect similar to the spaces mentioned below. *Fig. 897.* is double the scale of *fig. 896.*

m m', *fig. 897.*, are basins of reception, distributed before the doors of each of the chambers *f k f' k'*. The condensed mercury which flows out of the chambers is conveyed thither. *n n'* is a trench into which the mercury, after being lifted into the basins *m*, is poured, so that it may run towards a common chamber *o*, in the sloping direction indicated by the arrows. *o* leads to the chamber where the mercury is received into a porphyry trough; out of which it is laded and packed up in portions of 50 or 100 lbs. in sheep-skins prepared with alum. *p p'*, *fig. 896.*, are vaulted arches, through which a circulation may go on round the furnace *a b c d*, on the ground level. *q q'* are the vaults of the upper stories. *r r'*, *fig. 898.*, vaults which permit access to the tunnels *e e'*, *fig. 896.*

s s' and *t t'*, *fig. 898.*, are the doors of the chambers *f k* and *f' k'*. These openings are shut during the distillation by wooden doors faced with iron, and luted with a mortar of clay and lime. *u u'* is the door of the vaults 1. to 7. of the furnace represented in

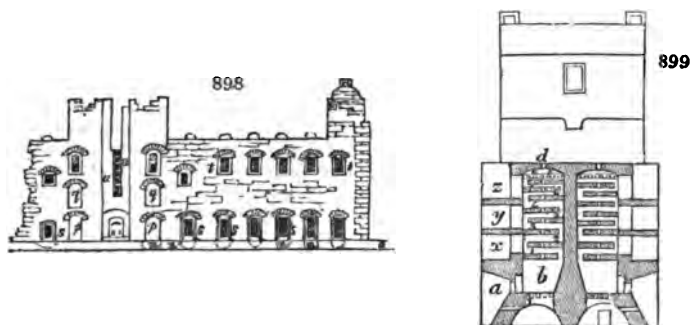


fig. 896. These openings are hermetically shut, like the preceding. *v v'*, *fig. 896.*, are superior openings of the chambers, closed during the operation by luted plugs; they are opened afterwards to facilitate the cooling of the apparatus, and to collect the mercurial soot. *x y z*, *fig. 899.*, are floors which correspond to the doors *u u'* of the vaults 1. to 7., *fig. 898.* These floors are reached by stairs set up in the different parts of the building, which contains the whole apparatus.

On the lower arches the largest blocks of metalliferous rock are laid; over these the less bulky fragments are arranged, which are covered with the shivers and pieces of less dimension. On the middle vaults, the small ore is placed, distributed into cylindrical pipkins of earthenware, of 10 inches diameter and 5 inches depth. The upper vaults receive likewise pipkins filled with the sands and pastes called *schlich*.

In 3 hours, by the labour of 40 men, the two double sets of apparatus are charged, and all the apertures are closed. A quick fire of beech-wood is then kindled; and when the whole mass has become sufficiently heated, the sulphuret of mercury begins to vapourize; coming into contact with the portion of oxygen which had not been carbonated, by combustion, its sulphur burns into sulphurous acid, while the mercury becomes free, passes with the other vapours into the chambers for condensing it, and precipitates in the liquid form at a greater or less distance from the fire-place. The walls of the chambers and the floors, with which their lower portion is covered, are soon coated over with a black mercurial soot, which, being treated anew, furnishes 50 per cent. of mercury. The distillation lasts from 10 to 12 hours; during which time the whole furnace is kept at a cherry-red heat. A complete charge for the two double apparatus, consists of from 1000 to 1300 quintals of ore, which produce from 80 to 90 quintals of running mercury. The furnace takes from 5 or 6 days to cool, according to the state of the weather; and if to that period be added the time requisite for withdrawing the residuums, and attending to such repairs as the furnace may need, it is obvious that only one distillation can be performed in the course of a week.

In the works of Idria, in 1812, 56,686 quintals and a half of quicksilver ores were distilled, after undergoing a very careful mechanical preparation. They afforded 4832 quintals of running mercury; a quantity corresponding to about 8½ per cent. of the ore. These smelting works are about 180 feet long and 30 feet high.

Upon the preceding three systems of smelting mercurial ores, I shall now make some observations.

It has been long well known, that quicksilver may be most readily extracted from cinnabar, by heating it in contact with quicklime. The sulphur of the cinnabar com-

bines, by virtue of a superior affinity with the lime, to the exclusion of the quicksilver, to form sulphurets of lime and calcium, both of which being fixed *Aspars*, remain in the retort while the mercury is volatilized by the heat. In a few places, *hammerschlag*, or the iron cinder, driven off from the blooms by the tilting hammer, has been used instead of lime in the reduction of this mercurial ore, whereby sulphurous acid and sulphuret of iron are formed.

The annual production of the Bavarian Rhine provinces has been estimated at from 400 to 550 quintals; that of Almaden, in the year 1827, was 22,000 quintals; and of Idria, at present, is not more than 1800 quintals.

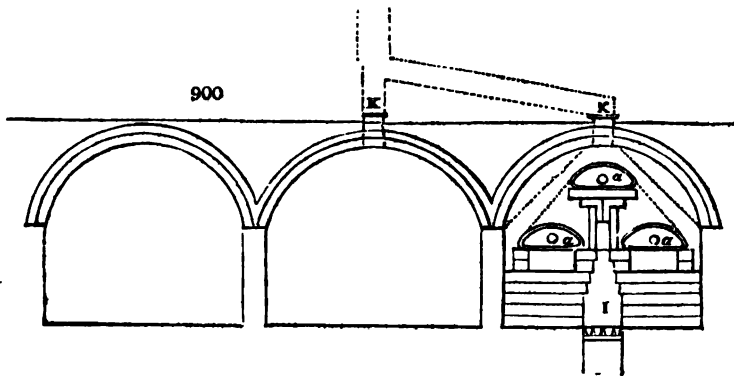
All the plans hitherto prescribed for distilling the ore along with quicklime, are remarkably rude. In that practised at Landsberg by Obermoschel, there is a great waste of labour, in charging the numerous small cucurbits; there is a great waste of fuel in the mode of heating them; a great waste of mercury by the imperfect luting of the retorts to the receivers, as well as the imperfect condensation of the mercurial vapours; and probably a considerable loss by pilfering.

The modes practised at Almaden and Idria are, in the greatest degree, barbarous; the ores being heated upon open arches, and the vapours attempted to be condensed by enclosing them within brick or stone and mortar walls, which can never be rendered either sufficiently tight or cool.

To obviate all these inconveniences and sources of loss, the proper chemical arrangements suited to the present improved state of the arts ought to be adopted, by which labour, fuel, and mercury, might all be economized to the utmost extent. The only apparatus fit to be employed is a series of cast-iron cylinder retorts, somewhat like those employed in the coal gas works, but with peculiarities suited to the condensation of the mercurial vapours. Into each of these retorts, supposed to be at least one foot square in area, and 7 feet long, 6 or 7 cwt. of a mixture of the ground ore with the quicklime, may be easily introduced, from a measured heap, by means of a shovel. The specific gravity of the cinnabar being more than 6 times that of water, a cubic foot of it will weigh more than $3\frac{1}{2}$ cwt.; but supposing the mixture of it with quicklime (when the ore does not contain the calcareous matter itself) to be only thrice the density of water, then four cubic feet might be put into each of the above retorts, and still leave $1\frac{1}{2}$ cubic feet of empty space for the expansion of volume which may take place in the decomposition. The ore should certainly be ground to a moderately fine powder, by stamps, iron cylinders, or an edge wheel, so that when mixed with quicklime, the cinnabar may be brought into intimate contact with its decomposer, otherwise much of it will be dissipated unproductively in fumes, for it is extremely volatile.

Figs. 900, 901, 902, represent a cheap and powerful apparatus which I contrived at the request of the German Mines Company of London, and which is now mounted at Landsberg, near Obermoschel, in the Bavarian Rhein-Kreis.

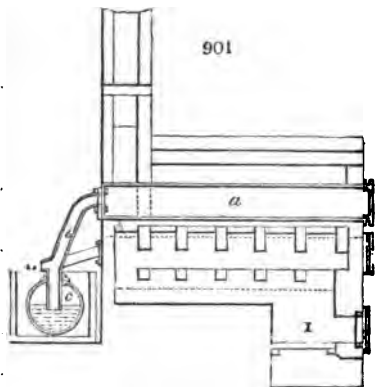
Fig. 900, is a section parallel to the front elevation of three arched benches of retorts.



of the size above specified. Each bench contains 3 retorts, of the form represented by *a a*. *I*, is the single fire-place or furnace, capable of giving adequate ignition by coal or wood, to the three retorts. The retorts were built up in an excellent manner, by an English mason perfectly acquainted with the best modes of erecting coal-gas retorts, who was sent over on purpose. The path of the flame and smoke is precisely similar to that represented in *fig. 670*, page 847, whereby the uppermost retort is immersed in a bath of uniformly ignited air, while the currents reverberated from the top, play round the two undermost retorts, in their way to the vent-flues beneath

them. The bottom of the uppermost retort is protected from the direct impulse of the flame by fire-tiles. The dotted lines *x x*, show the paths of the chimneys which rise at the back ends of the retorts.

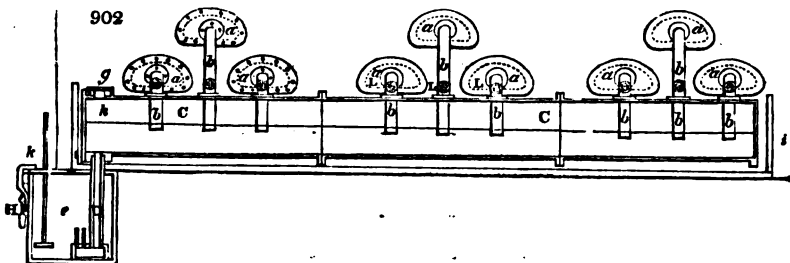
In the section, *fig. 901.*, *a* is the body of the retort; its mouth at the right hand end



is shut, as usual, by a luted iron lid, secured with a cross-bar and screw-bolts; its other end is prolonged by a sloping pipe of cast iron, 4 inches in diameter, furnished with a nozzle hole at *u*, closed with a screw plug. Through this hole a wire rammer may be introduced, to ascertain that the tube is pervious, and to cleanse it from the mercurial soot, when thought necessary. *c*, is a cross section of the main condenser, shown in a longitudinal section at *c c*, *fig. 902*.

This pipe is 18 inches in diameter, and about 20 feet long. At *a a*, &c., the back ends of the retorts are seen, with the slanting tubes *b b*, &c., descending through orifices in the upper surface of the condenser pipe, and dipping their ends just below the water-line *h i*. *g*, is the cap of a water valve, which removes all risk from sudden expansion or condensation. The

condenser is placed within a rectangular trough, made either of wood or stone, through which a sufficient stream of water passes to keep it perfectly cool, and repress every trace of mercurial vapour, and it is laid with a slight inclination from *i* to *h*, so that the condensed quicksilver may spontaneously flow along its bottom, and pass through the



vertical tube *d* into the locked up iron chest, or magazine *e*. This tube *d* is from the beginning closed at bottom, by immersion in a shallow iron cup, always filled with mercury. *k* is a graduated gauge rod, to indicate the progressive accumulation of quicksilver in the chest, without being under the necessity of unlocking it.

This air-tight apparatus was erected some years ago, and has been found to act perfectly well; I regret, however, that my professional engagements at home have not hitherto permitted me to conduct its operations personally for some days. The average samples of cinnabar ore from Obermoeschel are ten times poorer than those of Almaden. Were such an apparatus as the above, with some slight modifications which have lately occurred to me, mounted for the Spanish mines, I am confident that their produce in quicksilver might be nearly doubled, with a vast economy of fuel, labour, and human life. The whole cost of the 9 large retorts, with their condensing apparatus, iron magazine, &c., was very little more than *two hundred pounds*! As the retorts are kept in a state of nearly uniform ignition, like those of the gas works, neither they nor the furnaces are liable to be injured in their joints by the alternate contractions and expansions, which they would inevitably suffer if allowed to cool; and being always ready heated to the proper pitch for decomposing the mercurial ores, they are capable of working off a charge, under skilful management, in the course of 3 hours. Thus, in 24 hours, with a relay of labourers, 8 charges of at least 5 cwts. of ore each might be smelted—2 tons, with 3 retorts, and 6 tons with 9 retorts; with a daily product from the rich ores of Almaden, or even Idria, of from 12 cwts. to 20 cwts. Instead of 3 benches of 3 retorts each, I would recommend 15 benches, containing 45 retorts, to be erected for either the Almaden or Idria mines; which, while they would smelt all their ores, could be got for a sum not much exceeding 1000*l.*, an outlay which they would reimburse within a month or two.

The following letter from Dr. Tobin gives an interesting account of the mercurial mines in California.

"That part of California where I have been residing, and that which I have just visited, consists of three long ranges of trapp mountains, with two wide valleys dividing them, the valley of the San Joaquin, and the valley of Santa Clara. Near this last place are the quicksilver mines of New Almaden, where I have been working. The matrix of the cinnabar ore is the same trapp of which the mountain ranges are composed, and as yet only one great deposit of this ore has been found, though *traces* of quicksilver ores have been discovered in other places. The ores are composed solely of sulphuret of mercury, (averaging 36 per cent.), red oxide of iron and silica; and had the mine been properly worked from the commencement almost any quantity of ore might be extracted; it now, however, more resembles a gigantic rabbit warren than a mine. The owners have lately sent out an old German miner, an experienced and practical man, who, if he stays here? will eventually put it into some kind of order. Its greatest depth is about 150 feet, and the weekly extraction of ores varies from 100 to 150 tons. Upon arriving here I found the concern in such a state of disorganization, that, after waiting three months in vain, and not having received a single cylinder or piece of machinery, I returned to Mexico to fetch up one of the proprietors. During my absence the former director, who in his life had never seen a mine, much less smelting works, put up four of the cylinders, supporting them solely upon their two ends without any fire brick guards or pillars. Of course when heated they sunk or sagged in the middle. Upon my return with one of the owners, something like order was established by him, and I got 16 cylinders at work, producing 1400 to 1500 lbs. daily. The result to me was satisfactory, but not so to the proprietor, on account of the expense of fuel and labour: he accordingly got a blacksmith, who had been sent here to put up the water wheel, to build him a small furnace, without consulting me at all. This man sent a friend of his, not liking to come himself, to look at the plans I had of the furnaces of Idria and Almaden, and then erected a small and miserable furnace to hold one ton of ore, upon a *disimproved* plan of those of Idria. With this he obtained from the richest ores (65 to 72 per cent.) 38 per cent. of mercury, of course with the consumption of very little wood and with little labour; (the loss of percentage was not thought about!) The proprietor immediately determined to have six similar furnaces built, and with great regret allowed me to erect one good furnace, and afterwards a second one.

"Now take the results of the year's work, and you can judge whether the report sent you is true or not, that the Yankee blacksmith has superseded me or not. Before the year was half out, he got tired of attempting to compete with my furnaces, and left in disgust.

| | | | | | |
|--|---|---|---|---|----------------------|
| The cylinders produced | - | - | - | - | 251,616 lbs. Mercury |
| (but were stopped in November on account | | | | | |
| of expense of working) | | | | | |

| | | | | | |
|---|---|---|---|---|---------|
| The first furnace, working only from November 1st, to | | | | | |
| July 1st, 1851, gave | - | - | - | - | 620,513 |
| The second furnace, working only from March 18th | | | | | |
| to July 1st, gave | - | - | - | - | 383,825 |

Total 1,255,954

"The product of the Yankee's six furnaces, working for a much longer period, as they went into operation long before mine, was only 544,000 lbs. making a total product for the year of about 18,000 quintals."

Quicksilver is a substance of paramount value to science. Its great density and its regular rate of expansion and contraction by increase and diminution of temperature, give it the preference over all liquids for filling barometric and thermometric tubes. In chemistry it furnishes the only means of collecting and manipulating, in the pneumatic trough, such gaseous bodies as are condensable over water. To its aid, in this respect, the modern advancement of chemical discovery is pre-eminently due.

This metal alloyed with tin-foil forms the reflecting surface of looking glasses, and by its ready solution of gold or silver, and subsequent dissipation by a moderate heat, it becomes the great instrument of the arts of gilding and silvering copper and brass. The same property makes it so available in extracting these precious metals from their ore. The anatomist applies it elegantly to distend and display the minuter vessels of the lymphatic system, and secretory systems, by injecting it with a syringe through all their convolutions. It is the basis of many very powerful medicines, at present probably too indiscriminately used, to the great detriment of English society; for it is far more sparingly prescribed by practitioners upon the continent of Europe, not otherwise superior in skill or science to those of Great Britain.

The nitrate of mercury is employed for the *secretage* of rabbit and hare-skins, that is, for communicating to fur of these and other quadrupeds the faculty of felting, which they do not naturally possess. With this view the solution of that salt is applied to them lightly in one direction with a sponge. A compound amalgam of zinc and tin is probably the best exciter which can be applied to the cushions of electrical machines.

The only mercurial compounds which are extensively used in the arts, are factitious cinnabar or Vermilion , and corrosive sublimate. Quantity imported for home consumption in 1850, 355,079 pounds; in 1851, 27,370 pounds.

A large quantity of mercury or quicksilver is annually produced in Idria, a town in the duchy of Carniola, the inhabitants of which are chiefly occupied in its extraction. The quicksilver mines are extremely productive. The cinnabar ore yields, when very rich, 50 per cent. of this metal. This ore is a sulphuret of mercury, and gives up the latter metal by sublimation.

With the quicksilver mines of Idria is connected a manufactory of vermilion, which produced, in the year 1847, 981 cwt. of that pigment. The residue of the quicksilver is used up to some small extent, about 300 cwt., for technical purposes and preparations; but the greater portion of it is sent abroad. The exports of quicksilver amounted to an annual average of 2,341 cwt. (in the year 1846 they reached 5,478 cwt.), and of preparations derived from it, such as corrosive sublimate, calomel, &c., to 41 cwt. By the consumption of quicksilver, for the manufacture of vermilion and for other technical purposes, the value of the annual produce of the raw material is greatly increased. The mines have been worked for upwards of three centuries and a half, and were originally discovered by an accident.

MERCURY, BICHLORIDE OF; *Corrosive sublimate*; (*Deutochlorure de mercure*, Fr.; *Aetzendes Quecksilber sublimat*, Germ.) is made by subliming a mixture of equal parts of persulphate of mercury, prepared as above described, and sea-salt, in a stone-ware cucurbit. The sublimate rises in vapour, and encrusts the globular glass capital with a white mass of small prismatic needles. Its specific gravity is 5.14. Its taste is acrid, stypto-metallic, and exceedingly unpleasant. It is soluble in 20 parts of water, at the ordinary temperature, and in its own weight of boiling water. It dissolves in 2½ times its weight of cold alcohol. It is a very deadly poison. Raw white of egg swallowed in profusion is the best antidote. A solution of corrosive sublimate has been long employed for preserving soft anatomical preparations. By this means the corpse of Colonel Morland was embalmed, in order to be brought from the seat of war to Paris. His features remained unaltered, only his skin was brown, and his body was so hard as to sound like a piece of wood when struck with a hammer.

In the valuable work upon the dry rot, published by Mr. Knowles, secretary of the committee of inspectors of the navy, in 1821, corrosive sublimate is enumerated among the chemical substances which had been prescribed for preventing the dry rot in timber; and it is well known that Sir H. Davy had, several years before that date, used and recommended to the Admiralty and Navy Board, corrosive sublimate as an anti-dry-rot application. It has been since extensively employed by a joint-stock company for the same purpose, under the title of Kyan's patent.

MERCURY, PROTOCHLORIDE OF; *Calomel*; (*Protochlorure de mercure*, Fr.; *Versüßtes Quecksilber*, Germ.) This compound, so much used and abused by medical practitioners, is commonly prepared by triturating four parts of corrosive sublimate along with three parts of running quicksilver in a marble mortar, till the metallic globules entirely disappear, with the production of a black powder, which is to be put into a glass balloon, and exposed to a subliming heat in a sand bath. The calomel, which rises in vapour, and attaches itself in a crystalline crust to the upper hemisphere of the balloon, is to be detached, reduced to a fine powder, or levigated and elutriated. 200 lbs. of mercury yield 236 of calomel and 272 of corrosive sublimate.

The following more economical process is that adopted at the Apothecaries' Hall, London. 140 pounds of concentrated sulphuric acid are boiled in a cast-iron pot upon 100 pounds of mercury, till a dry persulphate is obtained. Of this salt, 124 pounds are triturated with 81 pounds of mercury, till the globules disappear, and till a proto-sulphate be formed. This is to be intimately mixed with 68 pounds of sea-salt, and the mixture, being put into a large stone-ware cucurbit, is to be submitted to a subliming heat. See CALOMEL.

From 190 to 200 pounds of calomel rise in a crystalline cake, as in the former process, into the capital; while sulphate of soda remains at the bottom of the alembic. The calomel must be ground to an impalpable powder, and elutriated. The vapours, instead of being condensed into a cake within the top of the globe or in a capital, may be allowed to diffuse themselves into a close vessel, containing water in a state of ebullition, whereby the calomel is obtained at once in the form of a washed impalpable powder. Calomel is tasteless and insoluble in water. Its specific gravity is 7.176.

For the compound of mercury with fulminic acid, see FULMINATE. *Periodide of mercury* is a bright but fugitive red pigment. It is easily prepared by dropping a solution of iodide of potassium into a solution of corrosive sublimate, as long as any precipitation takes place, decanting off the supernatant muriate of potash, washing and drying the precipitate.

MERCURY; *new test for*, by Mr. Morgan of Dublin. If a strong solution of iodide of potassium be added to a minute portion of any of the salts of mercury, placed on a

bright clean plate of copper, the mercury is immediately deposited in the metallic state; as a silvery stain upon the copper. No other metal is separated by like means. By this method corrosive sublimate may be detected in a drop of solution unaffected either by caustic potash or iodide of potassium. In a mixture of calomel and sugar, in the proportion of one grain to 200, a distinct metallic stain will be obtained with one grain, which of course contains $\frac{1}{200}$ of a grain of calomel. In like manner $\frac{1}{200}$ of a grain of peroxide of mercury may be detected, although the mixture with sugar is not in the least coloured by it. With the preparations of mercury in the undiluted state, this process acts with remarkable accuracy, the smallest quantity of calomel or peroxide, placed on copper as above, will give with iodide of potassium a distinct metallic stain. Mr. Morgan supposes that the iodide of potassium forms a soluble salt with the several salts of mercury, which is easily decomposed. — *Ph. Journ.*, Feb. 1852.

METALLIC ANALYSIS. Professor Liebig has lately enriched this most useful department of practical chemistry, by the employment of the cyanide of potassium prepared in his economical method (see this article). This salt is the best re-agent for detecting nickel in cobalt. The solution of the two metals being acidulated, the cyanide is to be added until the precipitate that first falls is redissolved. Dilute sulphuric acid is then added, and the mixture being warmed and left in repose, a precipitate does not fail to appear sooner or later, which is a compound of nickel. Cyanide of potassium serves well to separate lead, bismuth, cadmium, and copper, four metals often associated in ores. On adding the cyanide in excess to the solution of these metals in nitric acid, lead and bismuth fall as carbonates, and may be parted from each other by sulphuric acid. Sulphuretted hydrogen is passed in excess through the residuary solution, and the mixture being heated, a small quantity of cyanide is added: a yellow precipitate indicates cadmium; and a black precipitate falls on the solution of hydrochloric acid, if copper be present.

If into a crucible (containing the cyanide fused by heat), a little of any metallic oxide be thrown at intervals, it will be almost immediately reduced to the reguline state. When the fluid mass is afterwards decanted, the metal will be found mixed with the white saline matter, from which it may be separated by water.

Even metallic sulphurets are reduced to the state of pure metals by being projected in a state of fine powder into the fused cyanide. When an iron ore is thus introduced, along with carbonate of potash or soda, and the mixture is heated to fusion, which requires a strong red heat, the alumina and silica of the ore fuse into a slag; from which, on cooling, the metallic iron may be separated by the action of water, and then weighed. If manganese exist in the ore, it remains in the state of protoxide; to be determined by a separate process. When oxide of copper is sprinkled on the surface of the fused cyanide, it is immediately reduced, with the disengagement of heat and light. The mixture being poured out of the crucible and concreted, is to be ground and washed, when a pure regulus of copper will be obtained.

The process of reduction is peculiarly interesting with the oxides of antimony and tin; being accomplished at a low red heat, hardly visible in day-light. Even the sulphurets of these metals are immediately stripped of their sulphur, with the formation of sulpho-cyanide of potassium.

Cyanide of potassium, mixed with carbonate of soda, is an excellent re-agent in blow-pipe operations for distinguishing metals. The reductions take place with the utmost facility, and the fused mixture does not sink into the charcoal, as carbonate of soda alone is apt to do in such cases. Hence the grains or beads of metal are more visible and can be better examined.

When the cyanide is heated along with the nitrates and chlorates (of potash), it causes a rapid decomposition, accompanied with light and explosions.

Arsenic may be readily detected in the commercial sulphuret of antimony, by fusing it with three-fourths of its weight of the cyanide in a porcelain crucible over a spirit lamp, when a regulus of antimony is obtained. The metal may then be easily tested for arsenic, since none of this volatile substance can have been lost, owing to the low temperature employed.

When arsenious acid, or orpiment, or any of the arseniates, are mixed with six times their weight of the mixture of cyanide and carbonate of soda in a tube with a bulb at one end, and heat applied with a spirit lamp to the glass, very beautiful rings of metallic mirror are formed by the reduced arsenic. The arseniates of lead and of peroxide of iron, however, do not answer to this test.

When sulphates of lead and barytes, along with silica, are mixed with four or five times their weight of the above mixed cyanide and carbonate, and fused, the sulphate of lead is reduced to the metallic state, the sulphate of barytes becomes a carbonate, and the silica gets combined with the alkali into a soluble glass.

METALLIC FUMES (CONDENSATION OF), by the Duke of Buccleugh. — In all great smelting works of lead and copper, the smoke rising from the furnaces is highly charged with the most noxious vapours, containing, besides other poisonous matter, a

large quantity of lead. Many attempts have been made to obviate this nuisance; and the system adopted by the exhibitor has been found to be very successful.

An oblong building in solid masonry, about 30 feet in height, is divided by a partition wall into two chambers, having a tall chimney or tower adjoining, which communicates with one of the chambers at the bottom. The smoke from the various furnaces, eight in number, and about 100 yards distance from the condenser, is carried by separate flues into a large chamber; from thence by a larger flue it enters the first chamber of the condenser at the very bottom, and is forced upwards in a zigzag course towards the top, passing four times through a shower of water constantly percolating from a pierced reservoir at the summit of the tower. The smoke is again compelled to filter a fifth time, through a cube of coke, some 2 feet square, through which a stream of water filters downwards, and which is confined to its proper limits by a vertical grating of wood. The smoke having reached the top, is now opposite the passage into the second or vacuum chamber.

This is termed the exhausting chamber, and is above 5 feet by 7 feet inside, and 30 or more feet in height. On its summit is fixed a large reservoir, supplied by an ample stream of water, always maintaining a depth of 6 to 10 inches.

The bottom of this tank is of iron, having several openings or slots, 12 in number, about an inch in width, and extending across the whole area of the reservoir, communicating directly with the chamber beneath. On this iron plate works a hydraulic slide plate, with openings corresponding in one position with those in the reservoir.

This plate receives a horizontal reciprocating motion from a water-wheel or other power, driven by means of a connecting-rod and crank.

In the middle of every stroke, the openings in the plate correspond with those in the bottom of the reservoir, and a powerful body of water falls as a shower-bath the whole height of the vacuum chamber; and, in doing so, sweeps the entire inside area, carrying with it every particle of insoluble matter held suspended in the vapours coming from the furnaces.

The atmospheric pressure, of course, acts in alternate strokes as a blast at the furnace mouths, and causes a draft sufficiently strong to force the impure vapours through the various channels in connection with the water, the wet coke and exhausting chambers, until it passes, purified and inert, into the open atmosphere.

The water saturated with particles of lead, &c. held in mechanical solution, finally passes into great dykes or reservoirs excavated for the purpose; and then deposits at leisure its rich charge of metal.

Formerly, the noxious fumes passing from the shafts of the furnaces poisoned the neighbourhood; the heather was burnt up, vegetation destroyed, and no animal could graze or bird feed near the spot.

Now, the green heather is seen in all its native luxuriance close around the establishment; and the sheep graze within a stone's throw of the chimney's base, and game on all sides take shelter.

METALLIC STATISTICS. The county of Cornwall is the most important mineral district of the United Kingdom for the number of its metalliferous minerals, many of which are not found in any other part of our islands. At a very early period of our history, mines were worked around the sea-coasts of Cornwall, of which the evidences are still to be seen at Tol-pedden-Penwith, near the Land's End; in Gwennap, near Truro; and at Cadgwith, near the Lizard Point. The traditionary statements that the Phœnicians traded for tin with the Britons in Cornwall are very fairly supported by corroborative facts; and it is not improbable that the *Ictes* or *Iktis* of the ancients was St. Michael's Mount, near Penzance.

In the reign of King John, the mines of the western portion of England appear to have been principally in the hands of the Jews. The modes of working must have been very crude, and their metallurgical processes exceedingly rough. From time to time the remains of furnaces, called Jew's houses, have been discovered, and small blocks of tin, known as Jew's tin, have not unfrequently been found in the mining localities.

Till a comparatively recent date, tin was the only metal which was sought for; and, in many cases, the mines were abandoned when the miners came to the yellows, that is, the yellow sulphuret of copper. The greatest quantity of tin has been produced by streaming (as washing the débris in the valleys is termed); and this variety, called stream tin, produces the highest price in the market.

The conditions under which these deposits occur are curious and instructive. At the Carnon Tin Stream works, north of Falmouth, the rounded pebbles of tin are found at a depth of about 50 feet from the surface, beneath the bottom of an estuary, where trees are discovered in their places of growth, together with human skulls, and the remains of deer, amidst the vegetable accumulations which immediately cover the stanniferous beds. According to Mr. Henwood's measurement, the section presents first about 50 feet of silt and gravel; then a bed of 18 inches in thickness of wood, leaves, nuts, &c. resting on the tin ground, composed of the débris of quartz, slate, and granite, and the

tin ore. At the Pentuan Works, near St. Austell, similar deposits occur, proving a material alteration in the level during the period expended in the formation of this deposit. Tin is also worked out of the lode in many parts, the ore occurring both in the slate and the granite formations. The modes of dressing the tin ore, preparing it for the smelter, and the process of smelting, are illustrated in the Exhibition.

There has been a remarkable uniformity in the quantity of tin produced in Cornwall during a long period, as will be seen from the following table:—

| Years. | Tons. | Price per cwt. |
|--------|-------|----------------|
| 1750 | 1,600 | |
| 1760 | 1,800 | |
| 1770 | 2,000 | |
| 1780 | 1,800 | 3 0 |
| 1790 | 2,000 | 3 15 |
| 1800 | 1,500 | 5 0 |
| 1810 | 1,400 | 7 0 |
| 1820 | 1,700 | 3 5 |
| 1830 | 3,500 | 3 0 |
| 1840 | 5,000 | 3 15 |

The produce of this metal within the last few years has been as follows:—

| Years. | Tons. |
|--------|--------|
| 1844 | 7,507 |
| 1845 | 7,739 |
| 1846 | 8,945 |
| 1847 | 10,072 |
| 1848 | 10,176 |
| 1849 | 10,719 |

The produce of zinc is not easily attainable, but it is now somewhat considerable, as is also that of arsenic, and of the iron pyrites, used in the manufacture of sulphuric acid.

The number of individuals employed in 59 Cornish copper mines was computed by Sir Charles Lemon in 1837, to be—

| | | | |
|----------|---|---|--------|
| Men | - | - | 10,624 |
| Women | - | - | 3,802 |
| Children | - | - | 3,490 |

The men alone work underground; the women and children are employed on the surface, picking and dressing the ore.

Mr. W. Henwood estimates the number employed at—

| | | | |
|----------|---|---|---------------|
| Men | - | - | 18,472 |
| Women | - | - | 5,764 |
| Children | - | - | 5,764 |
| | | | <u>30,000</u> |

Tin appears to have been raised in Cornwall from a very early period. Traditional evidence, supported by strong corroborative facts, appears to prove that the kingdoms around the Mediterranean Sea were supplied with tin from Cornwall by the Phœnician merchants at a very early date. The circumstance of this metal being found in the beds of streams, and in deposits at the base of the primary rocks, from which it could be obtained without much labour, may have been the cause of its being early known to the Britons.

The oxide of tin is usually found deposited in beds in water-worn pebbles, and mixed with the débris of the neighbouring hills. There can be but little doubt that these tin deposits are the result of the disintegrating action of the atmospheric causes and of water. Some of the tin beds, 30 or 50 feet from the present surface, contain vegetable matter, as branches of trees and large logs of wood; and at Carnon Stream Works, human skulls were discovered amidst the débris, 53 feet below the surface. Tin is also found in the lode, either as peroxide, cupreous-sulphuret of tin, or tin pyrites, the analysis of the peroxide giving peroxide of tin, 96.265; silica, 0.750; peroxide of iron and manganese, 3.395.

Many indications of early tin-mining are to be found in Cornwall, as stated in preceding note. For many centuries the Duke of Cornwall drew a large revenue from its tin. The tin, when smelted into blocks, was forwarded to the nearest coinage town, there to be stamped by the duchy officers, who cut a piece of the corner of each block, which was retained as the duchy's dues. In 1337, Edward the Black Prince was created Duke of Cornwall, and then the average profit of the coinage was 4,000 marks

per annum. In 1814, the revenues to the duchy from tin was about 8,500*l.*, and the average tin revenue from 1820 to the abolition of the coinages in October, 1838, has been estimated at 12,000*l.* per annum. In 1750, about 2,000 tons of tin were produced in Cornwall, and in 1838, about 5,000. Since that period the quantity can be accurately ascertained, the trade in tin being in the hands of a few, and the purchases of ore being usually made by private contract.

By the returns to five several orders made by the House of Commons, which were obtained by the exertions and perseverance of Sir J. J. Guest, Sir C. Lemon, and Mr. Evans (*M. P.* for North Derbyshire), we are enabled to lay before our readers a most correct account of the various exports and imports of iron and iron ore, hardware, cutlery, &c., copper ore, copper, tin, zinc, lead ore, and lead, for the year ending Jan 5. 1844.

Commencing with iron, it appears there was imported in the year, iron ore, 131 tons; chromate of iron, 1393 tons; pig-iron, 243 tons; unwrought iron in bars, 12,795 tons; bloom, 563 tons; rod-iron, 12 tons; old, broken, and cast-iron, 286 tons; cast-iron, only 8 tons; steel, unwrought, 1697 tons—of these, 97 tons only were entered by weight, the remainder by value, 11,035*l.* 6*s.* 9*d.* Of the several countries from which these importations came, the principal is Sweden, whence we have received of iron 10,909 tons, and steel 1558 tons, leaving but a small portion to divide between twenty other places.—Our exports of foreign iron have been, unwrought, in bars, 3986 tons; rod, 10 tons; hoops, 2 tons; cast-iron, 11 cwt.; steel, unwrought, 1456 tons. The total quantity of foreign iron retained for home consumption was 14,782 tons, upon which the net amount of duty was 14,563*l.*—The exportation of that staple produce of our own country, British iron, was as follows:—Bar-iron, 176,148 tons; bolt and rod, 22,625 tons; pig-iron, 154,770 tons; cast-iron, 16,449 tons; iron wire, 1508 tons; wrought-iron, consisting of anchors, grapnels, &c., 3058 tons; hoops, 14,591 tons; nails, 6020 tons; and all other sorts, except ordnance, 44,577 tons; old iron for manufacture, 5924 tons; and unwrought steel, 3199 tons. Those places which have taken the greatest portions of this produce are—Russia, 10,963 tons of bar-iron; Denmark, 10,447 tons bar, and 7010 tons pig; Prussia, 12,009 tons bar, 17,480 tons pig; Germany, 13,298 tons bar, 6322 tons pig, 1339 tons cast; Holland, 17,509 tons bar, 75,953 tons pig; 4317 tons cast; Belgium, 4279 tons cast; France, 4237 tons bar, 22,103 tons pig; Italy, 21,930 tons bar, 3982 tons bolt and rod, 3005 tons pig; Turkey, and Continental Greece, 6412 tons bar; East Indies and Ceylon, 20,620 tons bar, 2967 tons bolt; British North American Colonies, 6837 tons bar, 1995 tons cast; Foreign West Indies, 5043 tons bar, 1646 tons cast; and to the United States, 21,336 tons bar, and 7148 tons pig. The largest quantity of unwrought steel has been to the latter place—*viz.* 1336 tons.

Of British hardware and cutlery, we exported in the year 17,183 tons, valued at 1,745,518*l.*; the principal of which has been—to Germany, 1237 tons, value 159,889*l.*; East Indies, 1402 tons, value 142,607*l.*; British North American Colonies, 1129 tons, value 102,260*l.*; British West Indies, 997 tons, value 80,040*l.*; Foreign West Indies, 657 tons, value 48,609*l.*; United States, 4282 tons, value 448,341*l.*; Brazil, 943 tons, value 80,070*l.*; and divers other places, varying from 100 to 500 tons.

We now come to copper. Of foreign copper ores, we have imported 55,720 tons; and of metallic copper, unwrought and wrought plates, and coins, 805 tons. Of the ores, the greatest quantities have come from Cuba and Chili.

We have exported 1819 tons of British, and 650 tons of foreign tin—of which France has taken 626 tons, Russia 480 tons, Italy 183 tons, Turkey 250 tons, and the remainder distributed among twenty-seven places.

Of foreign zinc, we have imported as follows:—

| Countries from whence imported. | Tons. | cwt. | qrs. | lbs. |
|---------------------------------|-------|--------|------|--------------|
| Denmark | - | - | - | 268 19 2 21 |
| Prussia | - | - | - | 6860 15 3 22 |
| Germany | - | - | - | 3000 1 2 11 |
| Holland | - | - | - | 20 3 2 1 |
| Belgium | - | - | - | 21 9 0 9 |
| Syria and Palestine | - | - | - | 1 15 0 15 |
| Total import of foreign zinc | Tons | 10,173 | 4 | 3 23 |

Of this, we retained for home consumption 4102 tons, on which the nett duty was 223*l.* 2*s.* 10*d.*; and we have exported 1395 tons of British, and 6445 tons of foreign spelter.

Of foreign lead, we have imported 2863 tons—of which 2775 tons were pig and sheet, 68 tons ore, and 19 tons white lead; 157 tons were retained for home consumption, on which the duty was 165*l.*; and we imported from the Isle of Man, duty free, 2415 tons of lead ore. Our exportation of foreign lead amounted to 2439 tons—while of British, we exported, 176 tons of ore, 14,610 tons pig and sheet, 378 tons litharge, 707 tons red lead, and 1224 tons white lead—making a total of 17,097 tons.

— *Railway and Commercial Gazette*, May 18. 1844.

METALLIC STATISTICS.

An Account of Sales, by Public Ticketing, of the British and Foreign Copper Ores in Cornwall and Swansea, from the 30th of June, 1832, to the 30th of June, 1849, showing the Averages of the per Centage of Produce in Metal, Prices, computed Quantities of fine Copper, with General Averages, Total Produce in Metal, and Money Value of the whole. Also giving the Value of Ore computed to produce a Ton of Copper.

| In the Year ending | CORNWALL. | | | | | | | SWANSEA. | | | | | | | CORNWALL and SWANSEA Averages. | | | | |
|--------------------|---|---------------------------|-----------------------------------|---|-----------------------|---|---------------------------|-----------------------------------|---|-----------------------|--|---|--|--|--|--|--|--|--|
| | Computed Quantity of Ore in Tons of 21 Cwt. | Average Produce per Cent. | Computed Quantity of fine Copper. | Average Price of Ore per Ton of 21 Cwt. | Total Value in Money. | Computed Quantity of Ore in Tons of 21 Cwt. | Average Produce per Cent. | Computed Quantity of fine Copper. | Average Price of Ore per Ton of 21 Cwt. | Total Value in Money. | Total Produce of the whole in Tons of fine Copper. | Quantity of Ore to make a Ton of fine Copper. | Average Value of Cornish Ore to make a Ton of fine Copper. | Average Value of Swansea Ore to make a Ton of fine Copper. | Average Value of Swansea Ore to make a Ton of fine Copper. | | | | |
| 1833 | 138,300 | 8 | 11,186 | 6 1 | 863,709 | 13,101 | 8 | 1,138 | 7 5 | 90,006 | 19,343 | 77 5 | 76 15 | 83 0 | | | | | |
| 1834 | 143,296 | 7 | 11,223 | 6 4 | 897,503 | 16,113 | 7 | 1,890 | 7 7 | 123,631 | 12,806 | 79 3 | 79 3 | 82 10 | | | | | |
| 1835 | 140,617 | 7 | 12,373 | 6 18 | 893,403 | 26,771 | 9 | 2,833 | 7 15 | 123,690 | 16,103 | 73 15 | 73 15 | 84 14 | | | | | |
| 1836 | 140,981 | 6 | 11,640 | 6 17 | 867,752 | 24,366 | 8 | 2,649 | 9 17 | 240,095 | 18,489 | 83 5 | 83 5 | 89 9 | | | | | |
| 1837 | 140,753 | 7 | 10,829 | 6 9 | 918,618 | 24,316 | 9 | 2,800 | 9 18 | 338,978 | 14,783 | 85 1 | 84 17 | 86 9 | | | | | |
| 1838 | 145,988 | 7 | 11,037 | 5 17 | 867,780 | 43,931 | 6 | 2,906 | 11 4 | 481,323 | 17,433 | 76 16 | 74 1 | 81 9 | | | | | |
| 1839 | 159,551 | 7 | 12,451 | 5 17 | 933,298 | 49,474 | 6 | 7,295 | 13 1 | 687,566 | 19,747 | 77 9 | 74 1 | 81 9 | | | | | |
| 1840 | 137,600 | 7 | 11,038 | 5 16 | 872,758 | 45,279 | 6 | 8,473 | 11 19 | 674,013 | 20,211 | 83 2 | 81 5 | 89 11 | | | | | |
| 1841 | 135,600 | 7 | 10,982 | 5 16 | 813,249 | 45,343 | 6 | 10,250 | 14 14 | 818,746 | 19,374 | 83 2 | 81 5 | 89 11 | | | | | |
| 1842 | 135,181 | 7 | 9,998 | 5 16 | 804,446 | 45,831 | 6 | 9,463 | 13 6 | 803,313 | 20,758 | 84 19 | 83 2 | 86 7 | | | | | |
| 1843 | 144,806 | 7 | 10,996 | 5 11 | 815,246 | 60,550 | 6 | 9,463 | 13 6 | 803,313 | 20,758 | 84 19 | 83 2 | 86 7 | | | | | |
| 1844 | 152,677 | 7 | 11,247 | 5 6 | 815,246 | 65,580 | 6 | 11,108 | 13 9 | 862,563 | 20,758 | 77 8 | 73 12 | 81 13 | | | | | |
| 1845 | 157,000 | 7 | 12,449 | 5 6 | 885,351 | 62,950 | 6 | 10,349 | 13 1 | 749,959 | 22,356 | 75 18 | 73 12 | 79 9 | | | | | |
| 1846 | 156,912 | 7 | 12,449 | 5 6 | 885,351 | 64,987 | 6 | 9,788 | 13 1 | 748,915 | 22,356 | 70 13 | 68 5 | 73 8 | | | | | |
| 1847 | 149,674 | 8 | 11,966 | 5 11 | 866,735 | 53,294 | 6 | 8,857 | 13 2 | 676,069 | 30,833 | 71 6 | 71 6 | 76 10 | | | | | |
| 1848 | 155,616 | 8 | 12,878 | 5 6 | 893,080 | 60,731 | 6 | 8,645 | 13 3 | 676,069 | 30,833 | 69 8 | 66 2 | 76 6 | | | | | |
| 1849 | 144,983 | 8 | 12,063 | 4 19 | 716,917 | 49,126 | 6 | 9,011 | 13 5 | 604,345 | 31,064 | 67 12 | 64 3 | 73 16 | | | | | |
| Total Amt. | 2,496,782 | - | 193,733 | - | 14,456,600 | 800,610 | - | 132,243 | - | 9,671,330 | 318,125 | - | - | 9,127,863 | | | | | |
| Averages | 147,046 | 7-833 | 11,517 | 5 15 6 | 860,268 | 47,085 | 6 | 7,197 | 13 1 7 | 568,967 | 18,714 | 75 16 10 | 73 16 9 | 79 0 11 | | | | | |

30th June,

Sales of British Copper Ores in Cornwall and Swansea, in the Six Years ending the 30th of June, 1849; with the Quantities and Value of Ore, the Averages in each Year, Quantities of fine Copper in the Ore, Prices per Ton, Value in Money, &c.

| Year | Sales in Cornwall | Sales at Swansea | Tons of 21 Cwt. | Average Produce per Cent. | Fine Copper. | Average Price of Ore. | Value. | Total Value. | Quantities of Ore. | Average Produce per Cent. | Fine Copper. | Average Price. | Value of Ore in Money of Copper. |
|----------------------|-------------------|------------------|-----------------|---------------------------|--------------|-----------------------|---------|--------------|--------------------|---------------------------|--------------|----------------|----------------------------------|
| | | | | | | | | | | | | | |
| 1844 | - | - | 182,667 | 7½ | 11,947 | 5 6 10 | 816,946 | 981,000 | 173,281 | 7-088 | 12,968 | 5 9 11 | 73 8 4 |
| | - | - | 30,864 | 8-263 | 1,731 | 6 13 0 | 186,944 | | | | | | |
| 1845 | - | - | 187,000 | 7½ | 12,329 | 5 6 3 | 883,281 | 981,285 | 176,086 | 7-883 | 12,818 | 5 8 1 | 68 17 0 |
| | - | - | 19,086 | 8-201 | 1,679 | 6 1 11 | 116,004 | | | | | | |
| 1846 | - | - | 188,913 | 7 12-16 | 12,448 | 5 11 7 | 896,765 | 1,002,329 | 177,143 | 7-922 | 13,268 | 5 13 2 | 71 16 2 |
| | - | - | 18,229 | 8-288 | 1,810 | 6 6 9 | 115,544 | | | | | | |
| 1847 | - | - | 146,674 | 8 1-16 | 11,966 | 5 11 9 | 890,729 | 921,678 | 162,871 | 8-184 | 12,160 | 5 13 9 | 70 1 0 |
| | - | - | 14,857 | 8-015 | 1,194 | 6 2 4 | 91,140 | | | | | | |
| 1848 | - | - | 155,616 | 8½ | 12,670 | 5 6 0 | 888,080 | 921,019 | 170,228 | 8-488 | 14,264 | 5 8 2 | 64 2 5 |
| | - | - | 14,622 | 10-215 | 1,484 | 6 11 3 | 93,989 | | | | | | |
| 1849 | - | - | 144,863 | 8 5-15 | 12,083 | 4 19 0 | 716,917 | 783,086 | 155,865 | 8-428 | 12,043 | 5 0 6 | 60 0 8 |
| | - | - | 10,622 | 9-084 | 990 | 6 1 6 | 66,119 | | | | | | |
| Total Quantities | | | 1,016,093 | - | 81,211 | - | - | 8,331,708 | 1,016,093 | - | 81,211 | - | - |
| Average Amounts, &c. | | | - | - | - | - | - | 921,561 | 165,249 | 8-002 | 13,552 | 5 8 11 | 68 0 7 |

Quantities of Copper contained in Orce purchased by Smelters in Six Years ending the 30th of June, 1849; distinguishing British and Foreign Produce, Quantities purchased at Ticketings, imported by Smelters, or bought by Private Contract, aggregate Value, &c.

| | Copper produced from British Orce. | | | | Copper produced from Foreign Orce. | | | Total Purchases. | From British Orce. | From Foreign Orce. | Total Value. | |
|------------------|--|--------------|---------------------|--|--|---------------------|--|------------------|--------------------|--------------------|--------------|--|
| | Purchased by Private Contract. | | Total British Orce. | Purchased at Ticketings at Government. | Imported and bought by Private Contract. | Total Foreign Orce. | Total Value of British Orce, computed at Average Prices. | | | | | Total Value of Foreign Orce at Average Prices. |
| | Purchased at Ticketings in Bond and Strangers. | Copper Tons. | Copper Tons. | | | | | | | | | |
| 1844 | 12,968 | 1,973 | 14,941 | 9,387 | 3,387 | 12,674 | 37,315 | 1,099,903 | 1,005,591 | 2,006,454 | | |
| 1845 | 12,818 | 1,121 | 14,939 | 8,770 | 2,106 | 10,876 | 36,815 | 1,096,333 | 798,498 | 1,897,028 | | |
| 1846 | 12,958 | 997 | 14,955 | 8,378 | 2,214 | 11,029 | 28,047 | 1,073,984 | 848,677 | 1,922,801 | | |
| 1847 | 12,160 | 626 | 12,786 | 7,663 | 1,277 | 9,040 | 22,828 | 965,661 | 690,088 | 1,655,689 | | |
| 1848 | 14,354 | • 556 | 14,730 | 7,151 | • 1,212 | 6,463 | 23,183 | 943,846 | 631,543 | 1,575,489 | | |
| 1849 | 12,048 | • 500 | 12,543 | 8,021 | • 1,000 | 9,021 | 22,563 | 812,021 | 603,319 | 1,419,250 | | |
| Total Amounts - | 61,211 | 5,473 | 66,733 | 46,370 | 11,566 | 61,106 | 147,943 | 5,914,600 | 4,650,946 | 10,496,856 | | |
| Average per Ann. | 12,242 | 913 | 14,464 | 8,211 | 1,966 | 10,194 | 24,698 | 983,767 | 763,498 | 1,749,899 | | |

Note.—The four quantities in 1848 and 1849, marked with an asterisk, are not given as correct. The previous figures in the table may be relied upon. Those standing against 1849, being even sums, will be understood to be matter of computation. It is certain, however, that considerable parcels, especially of foreign orce, were purchased by private contract or imported; and the quantities here given may be regarded as quite below the amounts so purchased.

Quantities of Copper Ore imported from Chili, which paid Duty, in the Five Years 1843 to 1847 inclusive.

| Years. | Copper Ore which paid Duty. | Metallic Copper charged with Duty. | Average per Cent. of Metal in the Ore. | Amount of Duty received. | Rate of Duty computed at per Ton of Ore. | | | Rate of Duty computed at per Ton of Metal. | | | Mean Price of Cuba Copper. | Rate per Cent. of Duty on Value of Copper. | | |
|--------|-----------------------------|------------------------------------|--|--------------------------|--|----|----|--|----|----|----------------------------|--|---|-------|
| | | | | | £ | s. | d. | £ | s. | d. | | | £ | s. |
| 1843 | Tons. 19,264 | Tons. 5,580 | 29.06 | 34,308 | 1 | 15 | 5 | 6 | 3 | 8 | 83 | 5 | 0 | 7.267 |
| 1844 | 19,308 | 5,646 | 29.25 | 34,749 | 1 | 16 | 0 | 6 | 3 | 1 | 83 | 5 | 0 | 7.319 |
| 1845 | 10,324 | 3,034 | 29.48 | 23,563 | 2 | 1 | 8 | 6 | 4 | 6 | 88 | 10 | 0 | 7.084 |
| 1846 | 12,592 | 4,231 | 33.61 | 33,563 | 3 | 0 | 0 | 6 | 3 | 1 | 90 | 15 | 0 | 6.781 |
| 1847 | 8,653 | 3,079 | 35.63 | 15,260 | 2 | 4 | 6 | 6 | 5 | 1 | 96 | 10 | 0 | 6.480 |
| Totals | 71,337 | 22,160 | 31.15 | 135,933 | 1 | 18 | 6 | 6 | 3 | 6 | 86 | 17 | 0 | 6.980 |

Quantities of Copper Ore imported from Cuba, which paid Duty, in the Five Years 1843 to 1847 inclusive.

| Years. | Copper Ore which paid Duty. | Metallic Copper charged with Duty. | Average per Cent. of Metal in Ore. | Amount of Duty received. | Rate of Duty computed at per Ton of Ore. | | | Rate of Duty computed at per Ton of Metal. | | | Mean Price of Cuba Copper. | Rate per Cent. of Duty on Value of Copper. | | |
|--------|-----------------------------|------------------------------------|------------------------------------|--------------------------|--|----|----|--|----|----|----------------------------|--|---|-------|
| | | | | | £ | s. | d. | £ | s. | d. | | | £ | s. |
| 1843 | Tons. 31,335 | Tons. 5,279 | 16.84 | 26,226 | 0 | 16 | 9 | 4 | 19 | 4 | 83 | 5 | 0 | 5.968 |
| 1844 | 34,970 | 6,605 | 18.88 | 35,064 | 1 | 0 | 1 | 5 | 6 | 2 | 83 | 5 | 0 | 6.237 |
| 1845 | 41,171 | 6,802 | 16.04 | 31,747 | 0 | 15 | 8 | 4 | 16 | 3 | 86 | 10 | 0 | 5.483 |
| 1846 | 31,937 | 4,935 | 15.45 | 22,953 | 0 | 14 | 8 | 4 | 13 | 0 | 90 | 15 | 0 | 5.124 |
| 1847 | 23,897 | 3,843 | 16.08 | 17,816 | 0 | 14 | 10 | 4 | 13 | 9 | 96 | 10 | 0 | 4.806 |
| Totals | 163,380 | 27,264 | 16.69 | 133,806 | 0 | 16 | 8 | 4 | 18 | 2 | 86 | 17 | 0 | 5.943 |

Quantities of Copper Ore imported from Australia and other British Possessions, in the Five Years 1843 to 1847 inclusive.

| Year. | Copper Ore which paid Duty. | Metallic Copper charged with Duty. | Average per Cent. of Metal in the Ore. | Amount of Duty received. | Rate of Duty computed at per Ton of Ore. | Rate of Duty computed at per Ton of Metal. | Mean Price of Cube Copper. | Rate per Cent. of Duty on Value of Copper. |
|--------|-----------------------------|------------------------------------|--|--------------------------|--|--|----------------------------|--|
| 1843 | Tons. 13 | Tons. Not assayed. | - | £ 14 | - | £ s. d. | £ s. d. | Not assayed. |
| 1844 | 137 | 15 | 9.55 | 15 | 0 1 11 | - | 88 5 0 | 1.228 |
| 1845 | 969 | 187 | 19.90 | 169 | 0 4 1 | 1 1 0 | 88 10 0 | 1.186 |
| 1846 | 3,753 | 619 | 21.53 | 800 | 0 4 7 | 1 1 0 | 90 15 0 | 1.187 |
| 1847 | 6,722 | 1,526 | 24.19 | 3,795 | 0 5 2 | 1 1 0 | 96 10 0 | 1.068 |
| Totals | 11,601 | 3,647 | 23.23 | 3,798 | 0 4 10 | 1 1 0 | 88 17 0 | 1.128 |

Quantities of Foreign Copper Ore which paid Duty in the United Kingdom, in the Five Years 1843 to 1847 inclusive.

| Year. | Copper Ore which paid Duty. | Metallic Copper charged with Duty. | Average per Cent. of Metal in the Ore. | Amount of Duty received. | Rate of Duty computed at per Ton of Ore. | Rate of Duty computed at per Ton of Metal. | Mean Price of Cube Copper. | Rate per Cent. of Duty on Value of Copper. |
|--------|-----------------------------|------------------------------------|--|--------------------------|--|--|----------------------------|--|
| 1843 | Tons. 54,370 | Tons. 11,664 | 21.43 | £ 64,445 | 1 3 8½ | £ s. d. | £ s. d. | 6.641 |
| 1844 | 58,691 | 13,190 | 22.51 | 75,301 | 1 5 8 | 5 4 0 | 85 5 0 | 6.685 |
| 1845 | 56,119 | 11,172 | 19.90 | 55,646 | 1 0 10½ | 5 5 0 | 88 10 0 | 5.923 |
| 1846 | 50,944 | 10,661 | 20.92 | 64,056 | 1 0 2½ | 5 5 | 90 15 0 | 5.587 |
| 1847 | 40,491 | 9,083 | 22.31 | 40,964 | 1 0 3 | 4 1 8 | 96 10 0 | 4.687 |
| Totals | 260,615 | 55,710 | 21.38 | 293,313 | 1 3 6 | 5 1 4 | 88 17 0 | 5.927 |

NOTE.—The amount for 1848 has been presented to Parliament monthly; a statement which, with the annual returns, is introduced in another place. Since the passing of the Act of 1846, admitting the foreign ores at a nominal duty without regard to produce, the details furnished in the tables annexed to this have not been continued.

METALLIC STATISTICS.

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Imports of Foreign Copper and Copper Ore—continued.

RUSSIA.

| Year ending Jan 5. | Copper unwrought. | | | Part wrought. | | | Pipes and Coils. | | | Old, for remanufacture. | | | Ore. | | | Copper Manufactures. | | | | | |
|--------------------|-------------------|-----|---------|---------------|-----|---------|------------------|-----|---------|-------------------------|-----|---------|------|-----|---------|----------------------|-----|---------|----|----|----|
| | T. | ct. | qr. lb. | T. | ct. | qr. lb. | T. | ct. | qr. lb. | T. | ct. | qr. lb. | T. | ct. | qr. lb. | T. | ct. | qr. lb. | £ | s. | d. |
| 1832 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1833 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1834 | 5 | 1 | 3 | 9 | 0 | 0 | 0 | 0 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1835 | 5 | 1 | 0 | 23 | 26 | 19 | 1 | 18 | — | — | — | — | — | — | — | — | — | — | 7 | 10 | 0 |
| 1836 | 9 | 1 | 2 | 4 | 16 | 1 | 1 | 14 | — | — | — | — | — | — | — | — | — | — | 41 | 15 | 0 |
| 1837 | 0 | 0 | 3 | 22 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 4 | 0 | 0 |
| 1838 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 5 | 0 | 0 |
| 1839 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1840 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1841 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 3 | 0 | 0 |
| 1842 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 22 | 0 | 0 |
| 1843 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 46 | 15 | 6 |
| 1844 | 3 | 4 | 1 | 8 | — | — | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 24 | — | — | — | — | 2 | 17 | 0 |
| 1845 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 96 | 15 | 0 |
| 1846 | — | — | — | — | — | — | 1 | 5 | 2 | 14 | — | — | — | — | — | — | — | — | 62 | 10 | 0 |
| 1847 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 3 | 0 | 0 |
| 1848 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 14 | 15 | 0 |
| 1849 | — | — | — | — | — | — | 3 | 0 | 0 | 0 | 0 | 11 | 1 | 24 | — | — | — | — | 8 | 10 | 0 |

HOLLAND.

| | | | | | | | | | | | | | | | | | | | | | | |
|------|---|----|---|----|---|---|---|----|---|----|---|---|---|---|----|----|---|----|----|----|---|----|
| 1834 | — | — | — | — | — | — | 0 | 2 | 0 | 25 | — | — | — | — | — | — | — | — | 8 | 0 | 0 | |
| 1835 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 1 | 10 | 0 | |
| 1836 | 0 | 0 | 0 | 7 | — | — | 0 | 0 | 0 | 4 | 0 | 2 | 0 | 1 | 43 | 18 | 0 | 20 | 4 | 5 | 2 | 25 |
| 1837 | 0 | 17 | 3 | 16 | 0 | 1 | 3 | 12 | — | — | — | — | — | — | — | — | — | — | 23 | 3 | 2 | 23 |
| 1838 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 9 | 2 | 0 | 15 |
| 1839 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 10 | 18 | 0 | 13 |
| 1840 | 1 | 14 | 2 | 7 | 0 | 0 | 1 | 12 | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1841 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1842 | — | — | — | — | — | — | 0 | 0 | 0 | 14 | — | — | — | — | — | — | — | — | — | — | — | — |
| 1843 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1844 | — | — | — | — | — | — | 0 | 0 | 1 | 6 | — | — | — | — | — | — | — | — | — | — | — | — |
| 1845 | — | — | — | — | — | — | 0 | 1 | 2 | 23 | 0 | 0 | 2 | 0 | — | — | — | — | — | — | — | — |
| 1846 | — | — | — | — | — | — | 0 | 1 | 0 | 22 | — | — | — | — | — | — | — | — | — | — | — | — |
| 1847 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1848 | — | — | — | — | — | — | 0 | 1 | 0 | 18 | — | — | — | — | — | — | — | — | — | — | — | — |
| 1849 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |

NORWAY.

| | | | | | | | | | | | | | | | | | | | | | | |
|------|-----|----|---|----|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|---|---|
| 1835 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1836 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1837 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1838 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1839 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1840 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1841 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1842 | — | — | — | — | — | — | 73 | 17 | 0 | 11 | — | — | — | — | — | — | — | — | — | — | — | — |
| 1843 | 79 | 9 | 1 | 10 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1844 | — | — | — | — | — | — | 50 | 10 | 0 | 8 | — | — | — | — | — | — | — | — | — | — | — | — |
| 1845 | 140 | 5 | 3 | 6 | 45 | 14 | 3 | 22 | 23 | 12 | 1 | 2 | — | — | — | — | — | — | — | — | — | — |
| 1846 | 69 | 9 | 2 | 13 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1847 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1848 | 33 | 17 | 3 | 27 | 69 | 19 | 0 | 4 | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1849 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |

[T]

METALLIC STATISTICS.

Quarterly Sales of Copper Ores in Cornwall for the Six Years ending the 31st of December, 1849.

| | | | | Tons. | £ | s. | d. |
|----------------|--------------------|---|---|---------|---------|----|----|
| Quarter ending | March 31, 1844 | - | - | 29,874 | 219,019 | 3 | 0 |
| " | June 30, 1844 | - | - | 37,306 | 188,731 | 8 | 0 |
| " | September 30, 1844 | - | - | 28,073 | 195,636 | 17 | 6 |
| " | December 31, 1844 | - | - | 37,716 | 198,066 | 16 | 0 |
| Total | | | | 152,969 | 801,484 | 4 | 6 |
| Quarter ending | March 31, 1845 | - | - | 40,367 | 215,284 | 3 | 0 |
| " | June 30, 1845 | - | - | 40,844 | 226,373 | 3 | 0 |
| " | September 30, 1845 | - | - | 42,420 | 250,257 | 1 | 6 |
| " | December 31, 1845 | - | - | 38,996 | 228,019 | 18 | 6 |
| Total | | | | 162,627 | 919,984 | 6 | 0 |
| Quarter ending | March 31, 1846 | - | - | 29,335 | 207,697 | 10 | 0 |
| " | June 30, 1846 | - | - | 23,232 | 200,810 | 11 | 6 |
| " | September 30, 1846 | - | - | 37,784 | 195,486 | 16 | 0 |
| " | December 31, 1846 | - | - | 36,079 | 191,197 | 9 | 0 |
| Total | | | | 144,430 | 796,192 | 6 | 6 |
| Quarter ending | March 31, 1847 | - | - | 28,071 | 222,542 | 9 | 0 |
| " | June 30, 1847 | - | - | 34,875 | 204,628 | 4 | 6 |
| " | September 30, 1847 | - | - | 40,174 | 229,969 | 3 | 6 |
| " | December 31, 1847 | - | - | 40,000 | 215,362 | 14 | 0 |
| Total | | | | 153,120 | 872,436 | 10 | 0 |
| Quarter ending | March 31, 1848 | - | - | 37,537 | 202,517 | 9 | 0 |
| " | June 30, 1848 | - | - | 37,905 | 176,330 | 17 | 0 |
| " | September 30, 1848 | - | - | 35,297 | 164,409 | 10 | 6 |
| " | December 31, 1848 | - | - | 35,973 | 176,933 | 0 | 6 |
| Total | | | | 147,712 | 720,090 | 17 | 0 |
| Quarter ending | March 31, 1849 | - | - | 26,093 | 188,507 | 0 | 6 |
| " | June 30, 1849 | - | - | 26,631 | 187,167 | 15 | 6 |
| " | September 30, 1849 | - | - | 37,103 | 194,495 | 11 | 6 |
| " | December 31, 1849 | - | - | 36,508 | 193,444 | 11 | 6 |
| Total | | | | 146,335 | 763,614 | 19 | 0 |

Quarterly Sales of Copper Ores in Cornwall for the Year 1849.

| Quarter ending | Ore, in Tons of 21 Cwt. | Fine Copper. | Amount of Money. | | | Average per Cent. | Average Standard. | | | Per Ton. | | |
|----------------|-------------------------|--------------|------------------|----|----|-------------------|-------------------|----|----|----------|----|----|
| | | | £ | s. | d. | | £ | s. | d. | £ | s. | d. |
| March 31 | - | 26,093 | 2,981 | 11 | | 188,507 | 0 | 6 | 8½ | 96 | 12 | 0 |
| June 30 | - | 26,631 | 2,906 | 14 | | 187,167 | 15 | 6 | 7½ | 96 | 16 | 3 |
| September 30 | - | 37,103 | 2,992 | 17 | | 194,495 | 11 | 6 | 8½ | 97 | 14 | 1 |
| December 31 | - | 36,508 | 2,810 | 2 | | 193,444 | 11 | 6 | 7½ | 104 | 10 | 11 |
| Total | - | 146,335 | 11,691 | 4 | | 763,614 | 19 | 0 | 8 | 99 | 18 | 3 |

METALLIC STATISTICS.

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Imports of Foreign Copper and Copper Ore—continued.

SWEDEN.

| Year ending Jan. 5. | Copper unwrought. | | | Part wrought. | | | Plates and Coins. | | | Old, for manufacture. | | | Ore. | | | Copper Manufactures. | | | | | |
|---------------------|-------------------|-----|---------|---------------|-----|---------|-------------------|-----|---------|-----------------------|-----|---------|-------|-----|---------|----------------------|-----|---------|----|----|----|
| | T. | ct. | qr. lb. | T. | ct. | qr. lb. | T. | ct. | qr. lb. | T. | ct. | qr. lb. | T. | ct. | qr. lb. | T. | ct. | qr. lb. | £ | s. | d. |
| 1832 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1833 | — | — | — | 0 | 0 | 1 | 17 | — | — | — | — | — | 714 | 14 | 0 | 0 | — | — | 10 | 0 | 0 |
| 1834 | — | — | — | — | — | — | — | — | — | — | — | — | 866 | 6 | 0 | 32 | — | — | — | — | — |
| 1835 | — | — | — | — | — | — | — | — | — | — | — | — | 789 | 18 | 2 | 9 | — | — | — | — | — |
| 1836 | — | — | — | — | — | — | — | — | — | — | — | — | 635 | 0 | 3 | 10 | — | — | — | — | — |
| 1837 | 11 | 14 | 2 | 11 | — | — | — | — | — | — | — | — | 453 | 9 | 0 | 26 | — | — | — | — | — |
| 1838 | — | — | — | — | — | — | — | — | — | — | — | — | 1,906 | 8 | 3 | 18 | — | — | — | — | — |
| 1839 | 45 | 7 | 3 | 21 | — | — | — | — | 1 | 16 | 2 | 3 | 1,469 | 10 | 0 | 0 | — | — | — | — | — |
| 1840 | 277 | 11 | 2 | 8 | — | — | — | — | — | — | — | — | 718 | 5 | 2 | 11 | — | — | — | — | — |
| 1841 | 191 | 18 | 1 | 14 | — | — | — | — | — | — | — | — | 501 | 18 | 0 | 0 | — | — | 2 | 0 | 0 |
| 1842 | 195 | 6 | 0 | 3 | — | — | — | — | — | — | — | — | 23 | 10 | 0 | 0 | — | — | — | — | — |
| 1843 | 55 | 11 | 2 | 21 | — | — | — | — | 0 | 6 | 1 | 8 | — | 16 | 12 | 0 | 14 | — | 5 | 0 | 0 |
| 1844 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 0 | 5 | 0 |
| 1845 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1846 | — | — | — | 2 | 0 | 0 | 15 | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1847 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1848 | — | — | — | — | — | — | — | — | 0 | 7 | 3 | 24 | — | — | — | — | — | — | — | — | — |
| 1849 | 3 | 0 | 0 | 6 | 1 | 19 | 3 | 27 | — | — | — | — | — | — | — | — | — | — | — | — | — |

SUMMARY.

Imports of Copper and Copper Ore from the whole of Europe into the United Kingdom from 1832 to the 5th of January, 1849.

| Copper unwrought, in Bricks or Pigs, Rose Copper, and Cast Copper. | | | Part wrought, Bars, Rods, or Ingots, hammered or raised. | | | Plates and Coins. | | | Old, for manufacture. | | | Ore. | | | Copper Manufactures. | | | | | | | | | | | |
|--|-----|---------|--|-----|---------|-------------------|-----|---------|-----------------------|-----|---------|------|-----|---------|----------------------|-------|---------|-------------------|----|----|-------|----|-------|-------|----|----|
| | | | | | | | | | | | | | | | Entered by Weight. | | | Entered by Value. | | | | | | | | |
| T. | ct. | qr. lb. | T. | ct. | qr. lb. | T. | ct. | qr. lb. | T. | ct. | qr. lb. | T. | ct. | qr. lb. | T. | ct. | qr. lb. | £ | s. | d. | | | | | | |
| *23 | 16 | 0 | 26 | 0 | 1 | 3 | 11 | 0 | 0 | 1 | 11 | 1 | 14 | 0 | 5 | 714 | 14 | 0 | 4 | — | 2,990 | 13 | 4 | | | |
| 8 | 11 | 0 | 26 | 0 | 4 | 1 | 0 | 0 | 3 | 1 | 0 | 5 | 11 | 2 | 24 | 400 | 4 | 2 | 16 | — | 4,589 | 16 | 10 | | | |
| 11 | 8 | 0 | 6 | 0 | 3 | 3 | 19 | 0 | 16 | 0 | 23 | 2 | 6 | 3 | 23 | 880 | 18 | 2 | 6 | — | 3,878 | 11 | 10 | | | |
| 27 | 0 | 1 | 16 | 28 | 6 | 0 | 1 | 0 | 0 | 0 | 22 | 2 | 1 | 3 | 7 | 851 | 10 | 3 | 24 | 4 | 17 | 1 | 9 | 3,739 | 14 | 10 |
| 17 | 15 | 0 | 23 | 16 | 4 | 3 | 17 | 0 | 3 | 0 | 16 | 5 | 10 | 1 | 13 | 1,065 | 9 | 1 | 21 | 31 | 18 | 2 | 38 | 5,336 | 2 | 0 |
| 334 | 17 | 2 | 18 | 4 | 15 | 1 | 7 | 0 | 0 | 0 | 1 | 7 | 5 | 3 | 12 | 2,173 | 16 | 2 | 25 | 38 | 1 | 3 | 08 | 8,081 | 0 | 0 |
| 177 | 2 | 3 | 14 | 0 | 3 | 0 | 7 | 0 | 1 | 1 | 4 | 3 | 12 | 3 | 9 | 1,522 | 0 | 2 | 1 | 23 | 8 | 2 | 16 | 3,889 | 11 | 4 |
| 55 | 7 | 3 | 21 | 0 | 16 | 0 | 23 | 0 | 0 | 3 | 13 | 1 | 12 | 1 | 13 | 882 | 13 | 3 | 21 | 1 | 8 | 2 | 3 | 4,002 | 17 | 2 |
| 287 | 6 | 0 | 13 | 0 | 7 | 3 | 3 | 0 | 1 | 0 | 21 | 7 | 15 | 1 | 12 | 589 | 17 | 2 | 21 | 3 | 16 | 0 | 0 | 2,336 | 3 | 6 |
| 162 | 4 | 3 | 25 | 0 | 0 | 1 | 21 | 74 | 0 | 1 | 26 | 2 | 8 | 2 | 3 | 226 | 11 | 1 | 3 | 10 | 18 | 1 | 27 | 2,190 | 18 | 0 |
| 126 | 16 | 0 | 3 | 0 | 1 | 1 | 23 | 0 | 0 | 3 | 18 | 4 | 2 | 0 | 20 | 335 | 4 | 3 | 7 | 31 | 19 | 0 | 11 | 2,274 | 17 | 6 |
| 141 | 8 | 3 | 2 | 0 | 0 | 2 | 33 | 50 | 10 | 2 | 12 | 0 | 16 | 3 | 11 | 364 | 18 | 3 | 8 | 36 | 12 | 1 | 25 | 2,838 | 0 | 0 |
| 28 | 15 | 0 | 5 | 86 | 6 | 1 | 054 | 5 | 1 | 20 | 4 | 15 | 0 | 22 | 672 | 18 | 3 | 0 | 41 | 17 | 0 | 13 | 3,217 | 1 | 4 | |
| 140 | 14 | 1 | 4 | 0 | 8 | 1 | 18 | 1 | 15 | 2 | 4 | 6 | 10 | 3 | 11 | 674 | 5 | 1 | 20 | 25 | 18 | 3 | 12 | 2,990 | 18 | 11 |
| 69 | 10 | 0 | 3 | 2 | 1 | 3 | 20 | 5 | 0 | 2 | 27 | 1 | 11 | 1 | 18 | 860 | 18 | 2 | 26 | 49 | 11 | 0 | 16 | 3,624 | 17 | 8 |
| 44 | 9 | 0 | 1 | 70 | 19 | 0 | 22 | 0 | 18 | 0 | 2 | 3 | 11 | 0 | 8 | 715 | 17 | 2 | 16 | 49 | 2 | 1 | 2 | 4,689 | 9 | 7 |
| 194 | 0 | 0 | 17 | 70 | 7 | 0 | 659 | 18 | 0 | 13 | 6 | 10 | 0 | 12 | 316 | 6 | 2 | 5 | 42 | 15 | 1 | 0 | 4,222 | 11 | 6 | |
| 105 | 14 | 1 | 1 | 75 | 1 | 2 | 14 | 7 | 0 | 1 | 0 | 28 | 11 | 0 | 14 | 302 | 3 | 1 | 23 | - | - | - | - | 8,076 | 11 | 5 |

* In this table the returns are also made up for the years 1832-48.

Purchasers of Copper Ores at Ticketings, in Cornwall, in the Year 1849.

| Names of Companies. | First Quarter. | | | Second Quarter. | | | Third Quarter. | | | Fourth Quarter. | | | Total. | | |
|---------------------|----------------|---------|--------|-----------------|---------|-------|----------------|---------|------|-----------------|---------|-------|---------|---------|------|
| | Amount. | | | Amount. | | | Amount. | | | Amount. | | | Amount. | | |
| | Tons. | £. | d. | Tons. | £. | d. | Tons. | £. | d. | Tons. | £. | d. | Tons. | £. | d. |
| Williams & Co. | 8,619 | 50,559 | 6 11 9 | 9,660 | 53,201 | 17 9 | 7,558 | 46,272 | 4 0 | 9,389 | 54,714 | 7 9 | 35,126 | 204,747 | 19 5 |
| Vivian & Sons | 7,436 | 39,893 | 6 8 | 7,732 | 40,387 | 12 3 | 8,754 | 45,480 | 16 6 | 7,364 | 40,795 | 0 10 | 31,296 | 166,387 | 16 3 |
| Grenfell & Sons | 6,120 | 30,332 | 0 6 | 5,644 | 27,405 | 5 5 | 4,984 | 25,316 | 1 6 | 5,071 | 24,212 | 12 7 | 21,769 | 113,266 | 0 0 |
| Sims & Co. | 5,929 | 35,068 | 4 6 | 5,612 | 36,380 | 7 1 | 5,318 | 25,926 | 5 9 | 5,108 | 34,645 | 11 0 | 18,653 | 101,900 | 8 3 |
| Fremant & Co. | 4,985 | 22,961 | 16 6 | 4,661 | 23,933 | 11 11 | 4,392 | 22,963 | 4 11 | 4,935 | 22,501 | 18 0 | 15,627 | 59,969 | 5 2 |
| Rhines Royal | 2,373 | 12,977 | 9 6 | 1,971 | 8,469 | 13 1 | 2,851 | 12,929 | 0 6 | 2,444 | 13,102 | 2 4 | 9,789 | 49,478 | 5 7 |
| Schneider & Co. | 390 | 6,886 | 6 0 | 1,210 | 6,108 | 9 11 | 2,843 | 13,369 | 2 4 | 2,097 | 10,278 | 10 11 | 7,590 | 34,584 | 3 5 |
| Crown Copper | 176 | 686 | 10 3 | 241 | 1,440 | 19 1 | 283 | 138 | 16 0 | 316 | 2,218 | 0 1 | 596 | 4,484 | 4 5 |
| Total | 36,068 | 188,507 | 0 6 | 36,631 | 187,167 | 15 6 | 37,103 | 194,496 | 11 6 | 36,508 | 198,444 | 11 6 | 146,335 | 753,614 | 19 0 |

Purchasers of Copper Ores at Ticketings, in Swansea, in the Year 1849.

| Names of Companies. | First Quarter. | | | Second Quarter. | | | Third Quarter. | | | Fourth Quarter. | | | Total. | | | |
|------------------------------|----------------|--------|-------|-----------------|---------|------|----------------|---------|-------|-----------------|---------|-------|---------|---------|--------|-----|
| | Amount. | | | Amount. | | | Amount. | | | Amount. | | | Amount. | | | |
| | Tons. | £. | d. | Tons. | £. | d. | Tons. | £. | d. | Tons. | £. | d. | Tons. | £. | d. | |
| Williams & Co. | 2,174 | 27,061 | 4 0 | 2,633 | 32,089 | 9 9 | 2,653 | 26,721 | 15 6 | 2,643 | 28,910 | 17 6 | 11,812 | 141,223 | 12 2 | |
| Vivian & Sons | 1,126 | 53,165 | 12 4 | 2,622 | 59,371 | 13 6 | 1,174 | 18,018 | 7 0 | 2,150 | 36,570 | 14 0 | 9,887 | 117,692 | 12 2 | |
| Grenfell & Sons | 1,493 | 13,569 | 12 6 | 1,633 | 23,855 | 14 5 | 1,693 | 16,748 | 6 0 | 1,823 | 15,919 | 19 0 | 6,547 | 73,913 | 14 0 | |
| Freeman & Co. | 215 | 2,876 | 9 6 | 745 | 10,459 | 2 11 | 604 | 4,893 | 17 0 | 625 | 20,004 | 10 0 | 5,014 | 74,126 | 15 5 | |
| Schneider & Co. | 643 | 9,980 | 2 0 | 850 | 15,377 | 11 2 | 680 | 10,943 | 17 0 | 524 | 9,072 | 15 9 | 2,603 | 49,296 | 19 5 | |
| English Copper | 473 | 6,472 | 0 10 | 847 | 10,484 | 10 0 | 758 | 7,770 | 14 11 | 684 | 9,565 | 16 3 | 2,763 | 44,373 | 5 11 | |
| Crown Copper | 176 | 686 | 10 3 | 241 | 1,440 | 18 1 | - | - | - | 136 | 1,294 | 6 6 | 653 | 3,351 | 14 0 | |
| Mines Royal | 40 | 1,693 | 13 10 | 411 | 4,956 | 5 9 | - | - | - | 371 | 6,316 | 5 3 | 1,492 | 11,866 | 3 10 | |
| B. Smith | - | 598 | 0 0 | 538 | 9,659 | 7 - | 129 | 2,172 | 5 0 | 785 | 15,949 | 11 6 | 1,492 | 26,344 | 4 0 | |
| British & Foreign Copper Co. | - | - | - | - | - | - | 307 | 3,219 | 1 5 | - | 855 | 6,597 | 0 9 | 742 | 11,916 | 2 2 |
| Mason and Elkington | - | - | - | - | - | - | - | - | - | 264 | 4,389 | 12 6 | 264 | 4,389 | 12 6 | |
| Total | 7,893 | 97,781 | 9 6 | 14,925 | 206,908 | 8 6 | 9,663 | 104,914 | 1 6 | 11,212 | 137,694 | 0 6 | 23,896 | 364,598 | 16 0 | |

METALLIC STATISTICS.

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Account of Sales of Copper Ores in Cornwall, 1849.

FIRST QUARTER.

| Date of Sale. | Average Standard. | Average Produce. | Price. | Quantity of Ore. | Computed Quantity of fine Copper. | Amount of Sales. | Value of Ore to produce 1 Ton of Copper. |
|---------------|-------------------|------------------|---------|------------------|-----------------------------------|------------------|--|
| | £ s. d. | | £ s. d. | 21 Cwt. | Tons. Cwt. | £ s. d. | £ s. d. |
| January 11 | 87 7 0 | 86 | 4 12 6 | 1,813 | 152 18 | 8,376 13 0 | 54 15 8 |
| " 18 | 84 12 0 | 94 | 5 9 0 | 2,633 | 255 3 | 14,346 18 6 | 56 4 7 |
| " 25 | 93 10 0 | 71 | 4 12 0 | 3,841 | 304 0 | 17,874 10 0 | 58 16 0 |
| February 1 | 96 16 0 | 71 | 4 6 0 | 3,983 | 298 0 | 17,166 12 0 | 58 11 9 |
| " 8 | 91 16 0 | 9 | 5 10 0 | 2,145 | 192 19 | 11,819 1 0 | 61 5 1 |
| " 22 | 90 8 0 | 94 | 5 18 6 | 3,990 | 287 0 | 17,723 1 0 | 61 15 1 |
| March 1 | 104 0 0 | 7 | 4 10 6 | 2,564 | 178 14 | 11,535 16 6 | 64 11 1 |
| " 8 | 106 18 0 | 8 | 5 14 6 | 3,684 | 278 6 | 19,832 16 6 | 71 5 3 |
| " 15 | 104 12 0 | 84 | 6 5 6 | 3,577 | 231 2 | 16,818 1 0 | 72 15 6 |
| " 22 | 99 7 0 | 94 | 6 12 0 | 2,885 | 272 7 | 19,122 0 0 | 70 4 3 |
| " 29 | 107 5 0 | 71 | 5 6 0 | 3,665 | 276 10 | 19,596 6 6 | 70 17 7 |
| Total | 98 12 0 | 81 | 5 4 5 | 36,093 | 2,981 11 | 186,507 0 5 | 63 4 6 |

SECOND QUARTER.

| | | | | | | | |
|---------|----------|-------|--------|--------|----------|--------------|----------|
| April 5 | 106 13 0 | 76 | 5 6 0 | 3,942 | 296 8 | 20,997 8 6 | 70 7 4 |
| " 12 | 104 14 0 | 81 | 5 18 0 | 2,547 | 210 12 | 16,048 10 0 | 71 9 1 |
| " 19 | 99 17 0 | 94 | 6 16 6 | 2,741 | 262 15 | 18,699 8 6 | 71 3 4 |
| " 26 | 112 3 0 | 61 | 4 12 6 | 3,671 | 176 5 | 12,453 5 6 | 70 9 9 |
| May 3 | 105 8 0 | 71 | 5 6 6 | 3,791 | 290 11 | 20,206 0 0 | 69 10 11 |
| " 10 | 100 9 0 | 81 | 5 8 6 | 2,584 | 210 19 | 14,092 6 6 | 56 15 1 |
| " 17 | 93 18 0 | 94 | 6 7 6 | 3,333 | 232 15 | 15,733 11 0 | 68 12 7 |
| " 24 | 98 5 0 | 71 | 4 5 0 | 3,961 | 281 7 | 16,378 16 6 | 69 9 8 |
| " 31 | 93 1 0 | 71 | 4 9 0 | 3,948 | 305 18 | 17,612 1 0 | 67 11 2 |
| June 7 | 90 14 0 | 8 | 4 11 0 | 2,496 | 201 7 | 11,407 19 6 | 56 13 2 |
| " 21 | 86 16 0 | 9 | 5 2 0 | 3,929 | 264 18 | 14,916 18 0 | 56 8 6 |
| " 28 | 99 3 0 | 64 | 3 14 0 | 2,628 | 170 19 | 9,724 8 6 | 56 17 8 |
| Total | 98 16 2 | 7-585 | 2 2 | 36,681 | 2,906 14 | 187,167 15 6 | 64 7 10 |

THIRD QUARTER.

| | | | | | | | |
|-------------|----------|-------|--------|--------|----------|--------------|---------|
| July 5 | 96 17 0 | 74 | 4 12 0 | 3,596 | 274 6 | 16,679 0 6 | 60 16 1 |
| " 12 | 94 9 0 | 81 | 5 10 6 | 3,528 | 231 2 | 13,913 5 0 | 62 18 6 |
| " 19 | 91 11 0 | 10 | 6 9 0 | 2,115 | 212 14 | 13,662 17 0 | 64 4 8 |
| " 26 | 100 0 0 | 71 | 4 10 6 | 3,622 | 264 6 | 16,473 4 6 | 62 6 7 |
| August 2 | 98 14 0 | 71 | 4 8 0 | 3,881 | 280 15 | 17,037 2 6 | 60 13 8 |
| " 9 | 95 19 0 | 84 | 5 10 6 | 3,596 | 224 2 | 14,263 0 6 | 64 1 10 |
| " 23 | 94 1 0 | 94 | 6 2 6 | 3,041 | 296 19 | 18,624 9 6 | 62 14 5 |
| " 30 | 108 2 0 | 61 | 3 18 0 | 3,977 | 183 0 | 11,699 15 6 | 63 2 3 |
| September 6 | 103 3 0 | 71 | 5 8 0 | 3,801 | 300 10 | 30,649 12 6 | 68 7 8 |
| " 13 | 103 16 0 | 81 | 5 16 6 | 2,677 | 220 16 | 15,663 15 6 | 70 9 9 |
| " 20 | 99 17 0 | 81 | 5 14 0 | 3,467 | 233 0 | 16,475 3 0 | 70 14 2 |
| " 27 | 106 10 0 | 71 | 5 2 6 | 3,790 | 281 7 | 19,554 5 6 | 69 10 0 |
| Total | 97 14 1 | 8-066 | 5 4 10 | 37,103 | 2,992 17 | 194,495 11 6 | 64 19 9 |

FOURTH QUARTER.

| | | | | | | | |
|------------|-----------|-------|--------|--------|---------|--------------|----------|
| October 4 | 106 7 0 | 71 | 4 16 0 | 3,998 | 283 6 | 19,126 13 0 | 67 10 3 |
| " 11 | 102 7 0 | 81 | 6 1 0 | 1,926 | 164 19 | 11,687 15 6 | 70 8 0 |
| " 18 | 98 1 0 | 94 | 6 10 6 | 2,594 | 245 9 | 16,338 10 6 | 69 0 2 |
| " 25 | 110 8 0 | 61 | 4 0 6 | 2,713 | 163 7 | 10,905 6 0 | 63 11 3 |
| November 1 | 104 8 0 | 71 | 4 18 6 | 3,965 | 281 6 | 19,516 2 6 | 66 19 11 |
| " 8 | 102 1 0 | 81 | 5 11 0 | 3,577 | 209 5 | 14,267 8 6 | 68 3 8 |
| " 22 | 97 16 0 | 94 | 6 11 0 | 3,358 | 234 13 | 15,494 6 6 | 68 2 5 |
| " 29 | 108 0 0 | 7 | 4 16 0 | 4,220 | 293 16 | 20,121 16 0 | 68 9 9 |
| December 6 | 108 15 0 | 71 | 5 2 6 | 4,264 | 317 8 | 22,527 2 0 | 70 19 6 |
| " 13 | 104 18 0 | 8 | 5 12 0 | 3,847 | 229 8 | 16,124 19 0 | 70 5 10 |
| " 20 | 100 18 0 | 9 | 6 7 0 | 3,527 | 228 1 | 16,059 16 0 | 70 8 5 |
| " 27 | 110 17 0 | 64 | 4 10 6 | 3,379 | 156 4 | 10,773 16 0 | 68 19 6 |
| Total | 104 10 11 | 7-696 | 5 5 7 | 36,508 | 2,810 2 | 193,444 11 6 | 68 16 9 |

Produce of Lead Ore and Lead in the United Kingdom, for the Year 1848.

By ROBERT HUNT, Esq., Keeper of the Mining Records.

| Mines. | Lead Ore Returns. | Lead Returns. | Mines. | Lead Ore Returns. | Lead Returns. |
|-------------------------------------|-------------------|---------------|--------------------------------|-------------------|---------------|
| <i>Cornwall.</i> | | | <i>Derbyshire.</i> | | |
| Callington - - - | Tons. 957 | Tons. 632 | Sundry Mines - - - | Tons. 5,185 | Tons. 3,370 |
| Huel Mary Ann - - - | 334 | 250 | <i>Shropshire.</i> | | |
| Huel Trelawny - - - | 413 | 298 | Snailbeach - - - | 3,463 | 2,426 |
| Huel Trehane - - - | 421 | 279 | White Grit and Batholes - - - | 506 | 229 |
| Herodsfoot - - - | 731 | 570 | Bog Mine - - - | 139 | 72 |
| East Huel Rose - - - | 5,233 | 3,191 | Pennerley - - - | 22 | 16 |
| North Huel Rose - - - | 80 | 49 | <i>Somersetshire.</i> | | |
| Cargol - - - | 964 | 577 | Mendip Hills - - - | 41 | 29 |
| Oxnam - - - | 470 | 298 | <i>Yorkshire.</i> | | |
| Huel Rose - - - | 399 | 239 | Swale Dale and Arkendale - - - | 4,053 | 3,040 |
| Cubert - - - | 68 | 41 | Cononley - - - | 699 | 437 |
| Holmbush - - - | 154 | 90 | Grassington and Garnbury - - - | 1,159 | 707 |
| Callostock - - - | 179 | 110 | Pateley District - - - | 987 | 609 |
| <i>Devonshire.</i> | | | <i>Cardiganshire.</i> | | |
| Tamar - - - | 1,022 | 631 | Lisburne Mines - - - | 2,454 | 1,694 |
| Huel Adams - - - | 56 | 30 | Cwm-yatwyth - - - | 190 | 71 |
| East Tamar Consols - - - | 237 | 173 | Egarr-hir - - - | 116 | 70 |
| Huel Friendship - - - | 9 | 5 | Cwm-sebon - - - | 31 | 17 |
| Huel Betsey - - - | 6 | 3 | Llanfair - - - | 80 | 53 |
| Lydford Consols - - - | 4 | 3 | Goginan - - - | 1,238 | 816 |
| <i>Cumberland and Alston Moor.</i> | | | Gogerddan Mines - - - | 943 | 162 |
| Rampgill - - - | 494 | 989 | Nant-y-crelau - - - | 17 | 10 |
| Scaleburn - - - | 228 | 156 | Pen-y-bont-pren - - - | 39 | 22 |
| Carrs and Hanging Shaw - - - | 146 | 97 | Cefn-cwm-brwyno - - - | 36 | 24 |
| Capel Cleugh - - - | 139 | 92 | Llwyn-malys - - - | 51 | 33 |
| Small Cleugh - - - | 31 | 21 | Bwlch-cwm-erfin - - - | 40 | 26 |
| Middle Cleugh - - - | 30 | 20 | Bwlch Consols - - - | 289 | 192 |
| Guddamgill - - - | 50 | 33 | Nanteos - - - | 50 | 30 |
| Long Cleugh - - - | 1,664 | 1,142 | Aberystwith, small mines - - - | 20 | 10 |
| Brownhill - - - | 603 | 400 | Llanymaron - - - | 11 | 5 |
| Bentyfields Veins - - - | 35 | 21 | Llanbedarn - - - | 33 | 18 |
| Cowperdyke Heads - - - | 14 | 9 | Bron-berllan - - - | 15 | 7 |
| Brigalburn Veins - - - | 244 | 162 | <i>Cornwallshire.</i> | | |
| Brownley Hill Veins - - - | 227 | 143 | Penrhyn-du - - - | 21 | 14 |
| Bentfield Sun. V. E. Eag. - - - | 119 | 80 | <i>Carmarthenshire.</i> | | |
| Blagill Veins - - - | 76 | 51 | Nant-y-Mwyn - - - | 307 | 204 |
| Carrs West of Nent Vein - - - | 39 | 26 | <i>Flintshire.</i> | | |
| Grass Fields Veins - - - | 31 | 20 | Talargoch - - - | 1,500 | 980 |
| Galligill Syke Veins - - - | 176 | 117 | Fronfownog - - - | 1,685 | 1,168 |
| Galligill Burn - - - | 24 | 16 | Hendre - - - | 1,040 | 838 |
| Hudgill Burn - - - | 188 | 120 | Maes-y-safn - - - | 1,138 | 824 |
| Holyfields Veins - - - | 58 | 38 | Pen-y-rhenblas - - - | 1,160 | 819 |
| Wellig Cross Vein - - - | 98 | 66 | Mold Mines - - - | 219 | 153 |
| Rodderup Cleugh West End - - - | 1,470 | 980 | Long Rake - - - | 39 | 21 |
| Tyne Bottom Veins - - - | 80 | 54 | Milwr - - - | 117 | 81 |
| Park Grove Sun Vein - - - | 21 | 14 | Dingle and Deep Level - - - | 887 | 643 |
| Low Birch Bank - - - | 19 | 13 | Pary's Mine - - - | 21 | 15 |
| Dowkeburn West End - - - | 95 | 63 | Trelogan - - - | 15 | 10 |
| Sundry mines under 10 tons - - - | 44 | 29 | Westminster Mines - - - | 659 | 451 |
| Driggill Beck Waste - - - | 30 | 15 | Halkin Hall - - - | 39 | 26 |
| Dry Mill Mine - - - | 40 | 27 | Garreg-y-boeth - - - | 6 | 4 |
| Greensides - - - | 1,660 | 1,200 | Boderyddan - - - | 106 | 69 |
| Woodend - - - | 26 | 24 | Belgrave - - - | 375 | 261 |
| Force Cragg - - - | 43 | 32 | Bryog-gwyrog - - - | 11 | 7 |
| Keswick Mine - - - | 20 | 14 | Jamaica - - - | 935 | 599 |
| Slaty Syke - - - | 47 | 35 | Bwlch-y-ddaufryn - - - | 20 | 16 |
| Calvert - - - | 11 | 6 | Gwern-y-mynydd - - - | 18 | 13 |
| Dozey - - - | 13 | 9 | Mostyn - - - | 13 | 8 |
| Slow Craig - - - | 25 | 16 | Baglitt (ore sold at) - - - | 46 | 20 |
| Crossfell Mines - - - | 44 | 30 | Billings - - - | 45 | 20 |
| Sundry, under 10 tons - - - | 20 | 12 | Caelanycraig - - - | 14 | 7 |
| <i>Durham & Northumberland.</i> | | | Mostyn - - - | 13 | 5 |
| E. and W. Allendale and | | | Ciwmlittia - - - | 26 | 11 |
| Weardale - - - | 13,230 | 9,060 | <i>Montgomeryshire.</i> | | |
| Teedale Mines - - - | 3,327 | 2,490 | Llangynnog - - - | 51 | 31 |
| Yarnberry - - - | 100 | 75 | Cae-conroy - - - | 33 | 20 |
| Silver Tongue - - - | 139 | 95 | Rhos-wydol - - - | 26 | 15 |
| Derwent Mines - - - | 1,480 | 1,046 | Dwn-gwm, or Dyfagwm - - - | 18 | 9 |
| Stanhope Burn - - - | 220 | 160 | Craig-Rhiwarth - - - | 27 | 16 |
| Holly-well - - - | 67 | 48 | Bryndall and Pen-y-clyn - - - | 155 | 100 |
| Lane Head - - - | 24 | 17 | Gorn - - - | 43 | 30 |
| Aller Gill - - - | 12 | 8 | <i>Machynlleth, including</i> | | |
| Bollhope - - - | 13 | 9 | Delifs - - - | 345 | 300 |
| Fallow-field - - - | 61 | 45 | | | |
| Whitfield - - - | 142 | 105 | | | |
| <i>Westmoreland.</i> | | | | | |
| Duften and Silverband - - - | 246 | 184 | | | |
| Hilton and Marton - - - | 273 | 304 | | | |

| Mines. | Lead Ore Returns. | Lead Returns. | Mines. | Lead Ore Returns. | Lead Returns. |
|-------------------------|-------------------|---------------|---------------------------|-------------------|---------------|
| <i>Montgomeryshire.</i> | | | SCOTLAND. | | |
| Nantmelyn - - - | Tons. 19 | Tons. 18 | Woodhead - - - | Tons. 450 | Tons. 390 |
| Frontballan - - - | 15 | 7 | Afton Lead Mines - - - | 80 | 56 |
| <i>Merionethshire.</i> | | | Stronlton Mines - - - | 226 | 141 |
| Cowarch - - - | 74 | 42 | Cairnmore - - - | 476 | 311 |
| Tyddingwladus - - - | 18 | 12 | Black Craig - - - | 86 | 58 |
| IRELAND. | | | Lead Hills Mine - - - | 300 | 200 |
| Newtonards - - - | 616 | 365 | Wanlock Mine - - - | 950 | 650 |
| Conlig - - - | 314 | 179 | ISLE OF MAN. | | |
| Shallee - - - | 340 | 202 | Foxdale Mines, including | | |
| Glenmalur - - - | 45 | 25 | Fee's shipment, &c. - - - | 1,565 | 1,034 |
| Luganure - - - | 422 | 238 | Laxey - - - | 635 | 461 |
| Barristown - - - | 173 | 116 | Douglas - - - | 260 | 173 |

Table showing the Total Quantity of Lead Ore raised and Lead smelted in the United Kingdom in 1848.

| Districts. | Lead Ore. | Lead. |
|---------------------------------|---------------|---------------|
| | Tons. | Tons. |
| Cornwall - - - | 10,494 | 6,614 |
| Devonshire - - - | 1,354 | 844 |
| Cumberland - - - | 8,373 | 5,684 |
| Durham and Northumberland - - - | 18,815 | 14,698 |
| Westmoreland - - - | 519 | 389 |
| Derbyshire - - - | 5,185 | 3,370 |
| Shropshire - - - | 4,130 | 2,763 |
| Somersetshire - - - | 41 | 29 |
| Yorkshire - - - | 6,848 | 4,793 |
| | <u>55,698</u> | <u>39,142</u> |
| WALES:— | | |
| Cardiganshire - - - | 4,902 | 3,180 |
| Cardarvonshire - - - | 21 | 14 |
| Cardarvonshire - - - | 367 | 264 |
| Flintshire - - - | 10,056 | 7,069 |
| Montgomeryshire - - - | 927 | 601 |
| Merionethshire - - - | 92 | 54 |
| | <u>16,205</u> | <u>11,192</u> |
| IRELAND - - - | 1,912 | 1,188 |
| SCOTLAND - - - | 2,588 | 1,726 |
| ISLE OF MAN - - - | 2,521 | 1,665 |
| Making a Total of | <u>78,964</u> | <u>54,843</u> |

Lead Ore and Lead imported and exported during 1848.

Imported.—1,296 tons of lead ore; pig and sheet-lead, 3,788 tons: retained for home consumption, 2,157 tons.

Exported.—126 tons of lead ore; pig and rolled lead, 4,977 tons; shot, 1,151 tons; litharge, red and white lead, 2,292 tons; foreign lead, in sheet and pig, 3,747 tons.

The Welsh sales include also the following lead ores:—Australian, 69 tons; Belgian, 85 tons; German, 44 tons; Portugal, 79 tons; Prussian, 112 tons; Sardinian, 112 tons.

The total amount of lead ore raised and sold in the United Kingdom for the year 1848 was 78,964 tons, and metallic lead sold 54,843 tons; while in 1847, the amount of lead ore was 79,311 tons, and lead 53,410 tons—showing a decrease in the quantity of ore in 1848, as compared with a former year, of 347 tons, but an increase in the metal of 1,443 tons.

The price of English pig at the close of 1847 was 177. 10s. per ton, and at the same period of 1848, 155. 15s. per ton. A comparison of the two years thus shows no very great fluctuation in home trade; but, on referring to the imports and exports, we find a great increase in the latter year. The imports of lead ore in 1847 were 507 tons, and pig and sheet lead 264 tons, and the exports 86 tons of ore, and 2,426 tons of metal; while in 1848 the imports were 1,296 tons of ore, and 3,788 tons of metal; and the exports 135 tons of ore, and 6,128 tons of metal—showing an increase in the imports of 791 tons of ore, and 3,264 tons of metal; and in the exports of 49 tons of ore, and 3,633 tons of pig, sheet lead, and shot, and exclusive of manufactured metal in the shape of litharge and red and white lead.

Public Sales of Tin Mines in the Counties of Cornwall and Devon, reported in the Official Returns for the Year ending the 31st of December, 1849.

| Name of Mines. | First Quarter. | | | Second Quarter. | | | Third Quarter. | | | Fourth Quarter. | | | Total. | | | | | | | | | | | | | | | |
|-----------------------|------------------|-----|------------------|------------------|-----|------------------|------------------|-----|------------------|------------------|-----|------------------|------------------|-----|------------------|-----|--------|---|--------|--------|----|---|-------|---|---|--------|---|---|
| | Quantity of Ore. | | Amount of Money. | Quantity of Ore. | | Amount of Money. | Quantity of Ore. | | Amount of Money. | Quantity of Ore. | | Amount of Money. | Quantity of Ore. | | Amount of Money. | | | | | | | | | | | | | |
| | T. | ct. | lb. | T. | ct. | lb. | T. | ct. | lb. | T. | ct. | lb. | T. | ct. | lb. | | | | | | | | | | | | | |
| Crest Polgooth | 164 | 10 | 0 | 7,837 | 19 | 8 | 186 | 0 | 0 | 170 | 0 | 0 | 180 | 0 | 0 | 700 | 10 | 0 | 30,417 | 11 | 3 | | | | | | | |
| Chrysolite | 75 | 0 | 0 | 3,437 | 0 | 0 | 23 | 10 | 0 | 19 | 10 | 0 | 10 | 10 | 0 | 117 | 14 | 0 | 1,833 | 7 | 6 | | | | | | | |
| Wheat River | 83 | 0 | 0 | 4,280 | 7 | 6 | 25 | 10 | 0 | 7 | 10 | 0 | 10 | 10 | 0 | 43 | 0 | 0 | 4,780 | 7 | 6 | | | | | | | |
| Yarnoff | 15 | 8 | 18 | 850 | 4 | 8 | 67 | 18 | 8 | 30 | 15 | 20 | 50 | 8 | 0 | 98 | 18 | 0 | 1,238 | 18 | 2 | | | | | | | |
| Drake Walls | 37 | 10 | 0 | 1,784 | 6 | 8 | 95 | 15 | 0 | 1,080 | 19 | 4 | 28 | 17 | 1 | 16 | 86 | 2 | 2,177 | 18 | 7 | | | | | | | |
| Wes Wheat Jewel | 17 | 0 | 0 | 953 | 12 | 6 | 88 | 5 | 0 | 1,218 | 0 | 0 | 14 | 0 | 0 | 73 | 18 | 0 | 2,994 | 13 | 1 | | | | | | | |
| Wes Wheat | 19 | 2 | 0 | 883 | 12 | 6 | 10 | 0 | 0 | 481 | 3 | 6 | 9 | 0 | 0 | 49 | 0 | 0 | 1,344 | 11 | 0 | | | | | | | |
| East Cornish | 14 | 8 | 0 | 723 | 1 | 1 | 9 | 10 | 9 | 18 | 10 | 0 | 4 | 10 | 3 | 51 | 19 | 0 | 2,561 | 10 | 0 | | | | | | | |
| Ashburton United | 28 | 0 | 0 | 1,453 | 2 | 5 | 5 | 10 | 0 | 401 | 10 | 0 | 5 | 10 | 3 | 28 | 0 | 0 | 1,463 | 4 | 8 | | | | | | | |
| Butwick Consols | 90 | 16 | 0 | 4,899 | 18 | 0 | 5 | 10 | 0 | 283 | 4 | 8 | 9 | 10 | 0 | 88 | 0 | 0 | 1,453 | 2 | 5 | | | | | | | |
| Wheat Friendship | 7 | 19 | 1 | 481 | 18 | 8 | 3 | 0 | 0 | 118 | 5 | 0 | 2 | 0 | 0 | 27 | 19 | 1 | 1,041 | 18 | 0 | | | | | | | |
| West Wheat Providence | - | - | - | 481 | 18 | 8 | - | - | - | 117 | 3 | 6 | - | - | - | 7 | 19 | 1 | 981 | 18 | 0 | | | | | | | |
| South Friendship | - | - | - | - | - | - | 3 | 0 | 0 | - | - | - | 2 | 3 | 0 | 0 | 0 | 0 | - | 481 | 18 | 0 | | | | | | |
| North Friendship | - | - | - | - | - | - | 3 | 0 | 0 | - | - | - | 2 | 3 | 0 | 0 | 0 | 0 | - | 481 | 18 | 0 | | | | | | |
| Breck Tor | - | - | - | - | - | - | - | - | - | - | - | - | 4 | 2 | 0 | 4 | 2 | 0 | - | 548 | 15 | 1 | | | | | | |
| Wheat Fortune | - | - | - | - | - | - | 1 | 18 | 1 | 89 | 5 | 2 | 2 | 10 | 0 | 2 | 10 | 0 | - | 319 | 12 | 0 | | | | | | |
| Wheat Fortune | - | - | - | - | - | - | - | - | - | - | - | - | 4 | 10 | 0 | 4 | 10 | 0 | - | 599 | 4 | 0 | | | | | | |
| Mineral Court | - | - | - | - | - | - | 1 | 18 | 1 | 89 | 5 | 2 | 1 | 9 | 0 | 1 | 9 | 0 | - | 599 | 4 | 0 | | | | | | |
| Total | 554 | 5 | 1 | 27,065 | 11 | 8 | 415 | 13 | 3 | 17,845 | 8 | 4 | 487 | 16 | 0 | 15 | 17,065 | 1 | 9 | 16,514 | 2 | 0 | 1,794 | 5 | 2 | 77,680 | 3 | 9 |

Companies by whom the Ores were purchased.

| Companies. | First Quarter. | | | Second Quarter. | | | Third Quarter. | | | Fourth Quarter. | | | Total. | | | | | | | | | | | | | | | |
|------------------------|------------------|-----|------------------|------------------|-----|------------------|------------------|-----|------------------|------------------|-----|------------------|------------------|-----|------------------|-------|--------|----|-------|--------|----|---|-------|---|---|--------|---|---|
| | Quantity of Ore. | | Amount of Money. | Quantity of Ore. | | Amount of Money. | Quantity of Ore. | | Amount of Money. | Quantity of Ore. | | Amount of Money. | Quantity of Ore. | | Amount of Money. | | | | | | | | | | | | | |
| | T. | ct. | lb. | T. | ct. | lb. | T. | ct. | lb. | T. | ct. | lb. | T. | ct. | lb. | | | | | | | | | | | | | |
| Clanish Smelting Comp. | 126 | 0 | 0 | 6,448 | 17 | 8 | 108 | 12 | 0 | 2,119 | 10 | 6 | 70 | 4 | 0 | 3,207 | 18 | 2 | 2,507 | 18 | 2 | | | | | | | |
| Wilton & Co. | 75 | 0 | 0 | 3,645 | 19 | 8 | 69 | 7 | 2 | 2,714 | 13 | 11 | 64 | 16 | 3 | 3,170 | 0 | 7 | 2,184 | 0 | 7 | | | | | | | |
| Daubay & Co. | 104 | 17 | 1 | 5,072 | 7 | 5 | 86 | 12 | 3 | 3,649 | 9 | 5 | 46 | 1 | 3 | 1,978 | 4 | 8 | 1,978 | 4 | 8 | | | | | | | |
| H. J. Eschborn & Co. | 15 | 15 | 0 | 1,840 | 4 | 6 | 50 | 11 | 3 | 1,051 | 19 | 5 | 184 | 16 | 3 | 2,183 | 18 | 2 | 184 | 16 | 3 | | | | | | | |
| Wes Wheat | 7 | 19 | 1 | 481 | 18 | 8 | - | - | - | 4,315 | 10 | 0 | 112 | 16 | 2 | 2,464 | 18 | 11 | 2,464 | 18 | 11 | | | | | | | |
| Union Smelting Company | 7 | 19 | 1 | 481 | 18 | 8 | - | - | - | 4,315 | 10 | 0 | 112 | 16 | 2 | 2,464 | 18 | 11 | 2,464 | 18 | 11 | | | | | | | |
| Tyntonweath Company | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | | | | | |
| Total | 544 | 5 | 1 | 27,005 | 11 | 5 | 415 | 13 | 3 | 17,845 | 8 | 4 | 487 | 16 | 0 | 15 | 17,065 | 1 | 9 | 16,514 | 2 | 0 | 1,794 | 5 | 2 | 77,680 | 3 | 9 |

The whole produce of Tin Mines in the Counties of Cornwall and Devon must not be estimated by the above returns, inasmuch that much only relates to the public sales, to which we have access of information, while the greater portion is disposed of by private contract. Since the repeal of the coinage duty in 1838, it has been found impracticable to obtain any accurate returns, and hence the imperfect table herewith presented.

CORNISH COPPER ORES.

Annual average Produce, Price, and Standard for Nine Years, from 1841 to 1849, inclusive, of Copper Ores sold at Cornish Ticketing, with the highest and lowest Prices of Cake Copper in each Year.

| Year. | Standard. | | | Produce. | Price. | | | Cake Copper — per Ton. | | |
|-------|-----------|----|----|----------|--------|----|----|------------------------|----|---------|
| | £ | s. | d. | | £ | s. | d. | £ | s. | d. |
| 1841 | 123 | 1 | 0 | 7½ | 6 | 5 | 0 | 100 | to | 95 0 0 |
| 1842 | 112 | 18 | 0 | 7½ | 5 | 12 | 1 | 96 | to | 83 0 0 |
| 1843 | 109 | 8 | 0 | 7½ | 5 | 10 | 0 | 88 | to | 78 10 0 |
| 1844 | 107 | 8 | 0 | 7½ | 5 | 4 | 9 | 88 | to | 88 3 0 |
| 1845 | 106 | 2 | 0 | 7½ | 5 | 13 | 0 | 93 | to | 84 0 0 |
| 1846 | 102 | 2 | 0 | 7½ | 5 | 5 | 10 | 93 | to | 68 10 0 |
| 1847 | 103 | 11 | 0 | 8½ | 5 | 14 | 1 | 58 | to | 93 0 0 |
| 1848 | 90 | 13 | 0 | 8 5-16 | 4 | 18 | 9 | 98 | to | 87 0 0 |
| 1849 | 99 | 18 | 3 | 8 | 5 | 4 | 3 | 86 | to | 79 10 0 |

Declared Value of Exports of British and Irish Metals for the Years ending the 5th of January, 1847, 1848, 1849, and 1850.

| | 1847. | 1848. | 1849. | 1850. |
|------------------------|-----------|-----------|-----------|-----------|
| | £ | £ | £ | £ |
| Iron and steel - - - | 4,178,026 | 5,265,779 | 4,747,009 | 4,966,973 |
| Copper and brass - - - | 1,558,187 | 1,541,868 | 1,272,675 | 1,204,301 |
| Lead - - - - - | 147,170 | 179,344 | 117,181 | 287,337 |
| Tin, unwrought - - - | 107,456 | 159,466 | 143,486 | 141,577 |
| Tin plates - - - - | 639,223 | 462,889 | 530,061 | 711,649 |

Exports of English and Irish Metals and Minerals.

The following particulars are extracted from an account of the exports of the principal articles of British and Irish produce and manufactures in the twelve months ending on the 5th of January, 1846, 1847, 1848, 1849, and 1850.

| | 1846. | 1847. | 1848. | 1849. | 1850. |
|-----------------------|-----------|-----------|-----------|-----------|-----------|
| | £ | £ | £ | £ | £ |
| Coals, culm - - - | 578,635 | 971,174 | 976,377 | 1,088,221 | 1,088,148 |
| Earthenware - - - | 828,182 | 793,166 | 834,151 | 722,012 | 807,466 |
| Glass - - - - - | 357,421 | 262,547 | 292,038 | 287,573 | 277,175 |
| Hardware, cutlery - - | 2,183,300 | 2,180,587 | 2,346,255 | 1,860,150 | 2,198,597 |
| Machinery - - - - | 904,961 | 1,117,470 | 1,228,091 | 234,132 | 154,707 |
| Iron, steel - - - - | 3,501,895 | 4,178,026 | 5,272,942 | 4,777,965 | 4,947,643 |
| Copper, brass - - - | 1,694,441 | 1,558,187 | 1,467,498 | 1,267,945 | 1,863,287 |
| Lead - - - - - | 210,974 | 147,170 | 181,771 | 116,547 | 287,337 |
| Tin, unwrought - - - | 48,777 | 107,456 | 159,098 | 143,086 | 141,577 |
| Tin plates - - - - | 615,729 | 639,223 | 459,365 | 532,142 | 711,649 |
| Salt - - - - - | 218,302 | 205,005 | 260,591 | 266,480 | 254,126 |

The total amount of exports shows—in 1846, 53,298,026*l.*; in 1847, 51,227,604*l.*; in 1848, 50,897,790*l.*; in 1849, 48,946,226*l.*; and in 1850, 58,848,042*l.*

METALLURGY (*Erzkunde*, Germ.) is the art of extracting metals from their ores. This art, which supplies industry with the instruments most essential to its wants, is alike dependent upon the sciences of chemistry and mechanics; upon the former, as directing the smelting processes, best adapted to disentangle each metal from its mineralizer; upon the latter, as furnishing the means of grinding the ores, and separating the light stony parts from the rich metallic matter.

Notwithstanding the striking analogy which exists between common chemical and metallurgic operations, since both are employed to insulate certain bodies from others, there are essential differences which should be carefully noted. In the first place, the quantity of materials being always very great in metallurgy, requires corresponding adaptations of apparatus, and often produces peculiar phenomena; in the second place, the agents to be employed for treating great masses, must be selected with a view to economy, as well as to chemical action. In analytical chemistry, the main object being exactness of result, and purity of product, little attention is bestowed upon the value of the reagents, on account of the small quantity required for any particular process. But in smelting metals upon the great scale, profit being the sole object, cheap materials and easy operations alone are admissible.

The metallic ores, as presented by nature, are almost always mixed with a considerable number of foreign substances; and could not therefore be advantageously submitted to metallurgic operations, till they are purified and concentrated to a certain degree by various methods.

OF THE PREPARATION OF ORES FOR THE SMELTING HOUSE.

There are two kinds of *preparation*; the one termed mechanical, from the means employed, and the results obtained, consists in processes for breaking and grinding the ore, and for washing them so as to separate the vein-stones, gangues, or other mixed earthy matters, in order to insulate or concentrate the metallic parts.

Another kind of preparation, called chemical, has for its object to separate, by means of fire, various volatile substances combined in the ore, and which it is requisite to clear away, at least in a certain degree, before trying to extract the metals they may contain.

Lastly, an indispensable operation in several circumstances, is to discover, by simple and cheap methods, called *assays*, the quantity of metal contained in the different species of ores to be treated.

This head of our subject, therefore, falls under three subdivisions:—

§ 1. The mechanical preparation of ores, including *picking*, *stamping*, and different modes of washing.

§ 2. The chemical preparation, consisting especially in the roasting or calcination of the ores.

§ 3. The assay of ores, comprehending the mechanical part: that is, by washing; the chemical part, or assaying by the *dry way*; and the assays by the *moist way*.

Section 1. Of the mechanical preparation or dressing of ores.—I. The first picking or sorting takes place in the interior, or underground, workings, and consists in separating the fragments of rocks, that apparently contain no metallic matter, from those that contain more or less of it. The external aspect guides this separation; as also the feeling of density in the hand.

The substances when turned out to the day, undergo another *sorting*, with greater or less care, according to the value of the included metal. This operation consists in breaking the lumps of ore with the hammer, into fragments of greater or less size, usually as large as the fist, whereby all the pieces may be picked out and thrown away that contain no metal, and even such as contain too little to be smelted with advantage. There is, for the most part, a building erected near the output of the mine, in which the breaking and picking of the ores are performed. In a covered gallery, or under a shed, banks of earth are thrown up, and divided into separate beds, on each of which a thick plate of cast-iron is laid. On this plate, elderly workmen, women, and children, break the ores with hand hammers, then pick and sort them piece by piece. The matters so treated are usually separated into three parts; 1. the rock or sterile gangue, which is thrown away; 2. the ore for the stamping mill, which presents too intimate a mixture of rock and metallic substance to admit of separation by breaking and picking; and 3. the pure ore, or at least the very rich portion, called the *sorted mine* or the *fat ore*. On the sorting floors there remains much small rubbish which might form a fourth subdivision of ore, since it is treated in a peculiar manner, by sifting, as will be presently mentioned.

The distribution of fragments more or less rich, in one class or another, is relative to the value of the included metal, taking into account the expenses necessary for its extraction.

Thus in certain lead mines, pieces of the gangues are thrown away, which judged by the eye may contain 3 per cent. of galena, because it is known that the greater portion of this would be lost in the washings required for separating the 97 parts of the gangue, and that the remainder would not pay the expenses.

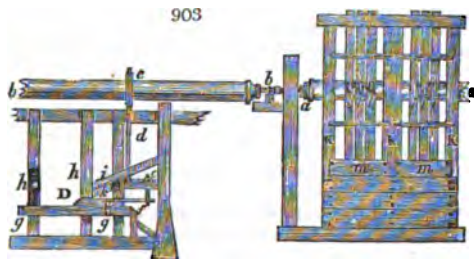
II. The very simple operations of *picking* are common to almost all ores; but there are other operations requiring more skill, care, and expense, which are employed in their final state of perfection only upon ores of metals possessing a certain value, as those of lead, silver, &c. We allude to the *washing* of ores.

The most simple and economical washings are those that certain iron ores, particularly the alluvial, are subjected to, as they are found near the surface of the ground agglutinated in great or little pieces. It is often useful to clean these pieces, in order to pick out the earthy lumps, which would be altogether injurious in the furnaces.

This crude washing is performed sometimes by men stirring in the midst of a stream of water, with iron rakes or shovels, the lumps of ore placed in large chests, or basins of wood or iron.

In other situations, this washing is executed more economically by a machine called a *buddle* or *dolly-tub* by our miners. A trough of wood or iron, with a concave bottom, is filled with the ore to be washed. Within the tub or trough, arms or iron handles are moved round about, being attached to the arbor of a hydraulic wheel. The trough is kept always full of water, which as it is renewed carries off the earthy matters, diffused through it by the motion of the machine, and the friction among the pieces of the ore. When the washing is finished, a door in one of the sides of the trough is opened, and the current removes the ore into a more spacious basin, where it is subjected to a kind of picking. It is frequently indeed passed through sieves in different modes. See LEAD and TIN, for figures of *buddles* and *dollies*.

III. *Stamping*. Before describing the refined methods of washing the more valuable ores of copper, silver, lead, &c., it is proper to point out the means of reducing them into a powder of greater or less fineness, by *stamping*, so called from the name *stamps* of the pestles employed for that purpose. Its usefulness is not restricted to preparing the ores; for it is employed in almost every smelting house for pounding clays, charcoal, scoria, &c. A stamping mill or pounding machine, *fig. 903*, consists of several



movable pillars of wood *l l l*, placed vertically, and supported in this position between frames of carpentry *x x x*. These pieces are each armed at their under end with a mass of iron *m*. An arbor or axle *a a*, moved by water, and turning horizontally, tosses up these wooden pestles, by means of wipers or cams, which lay hold of the shoulders of the pestles at *l l l*. These are raised in succession, and fall into an oblong trough below *m m*, scooped out in the ground, having its bottom covered either with plates of iron or hard stones. In this trough, beneath these pestles, the ore to be stamped is allowed to fall from a hopper above, which is kept constantly full.

The trough is closed in at the sides by two partitions, and includes three or four pestles; which the French miners call a *battery*. They are so disposed that their ascent and descent take place at equal intervals of time.

Usually a stamping machine is composed of several *batteries* (two, three, or four), and the arrangement of the wipers on the arbor of the hydraulic wheel is such that there is constantly a like number of pestles lifted at a time; a circumstance important for maintaining the uniform going of the machine.

The matters that are not to be exposed to subsequent washing are stamped dry, that is without leading water into the trough; and the same thing is sometimes done with the rich ores, whose lighter parts might otherwise be lost.

Most usually, especially for ores of lead, silver, copper, &c., the trough of the stamper is placed in the middle of a current of water, of greater or less force; which, sweeping off the pounded substances, deposits them at a greater or less distance onwards, in the order of the size and richness of the grain; constituting a first washing, as they escape from beneath the pestles.

In the dry stamping, the fineness of the powder depends on the weight of the pestles, the height of their fall, and the period of their action upon the ore; but in the stampers exposed to a stream of water, the retention of the matters in the trough is longer or shorter, according to the facility given for their escape. Sometimes these matters flow out of the chest over its edges, and the height of the line they must surmount has an influence on the size of the grain; at other times, the water and the pounded matter

which it carries off, are made to pass through a grating, causing a kind of sifting at the same time. There are, however, some differences in the results of these two methods. Lastly, the quantity of water that traverses the trough, as well as its velocity, has an influence on the discharge of the pounded matters, and consequently on the products of the stampers.

The size of the particles of the pounded ore being different, according to the variable hardness of the matters which compose them, suggests the means of classing them, and distributing them nearly in the order of their size and specific gravity, by making the water, as it escapes from the stamping trough, circulate in a system of canals called a *labyrinth*, where it deposits successively, in proportion as it loses its velocity, the earthy and metallic matters it had floated along. These metalliferous portions, especially when they have a great specific gravity like galena, would be deposited in the first passages, were it not that from their hardness being inferior to that of the *gangue*, they are reduced to a much finer powder, or into thin plates, which seem to adhere to both the watery and earthy particles; whence they have to be sought for among the finest portions of the pulverised *gangue*, called slime, *schlich*, or *schlumme*.

There are several methods of conducting the stamps; in reference to the size of the grains wished to be obtained, and which is previously determined agreeably to the nature of the ore, and of the *gangue*; its richness, &c. The height of the slit that lets the pounded matters escape, or the diameters of the holes in the grating, their distance, the quantity of water flowing in, its velocity, &c., modify the result of the stamping operation.

When it is requisite to obtain powder of an extreme fineness, as for ores that are to be subjected to the process of amalgamation, they are passed under millstones, as in common corn mills; and after grinding, they are bolted so as to form a species of flour; or they are crushed between rolls. See LEAD and TIN.

Washing of ores.

IV. The ores pounded under the stamps are next exposed to very delicate operations, both tedious and costly, which are called the *washings*. Their purpose is to separate mechanically the earthy matters from the metallic portion, which must therefore have a much higher specific gravity; for otherwise, the washing would be impracticable.

The medium employed to diminish the difference of specific gravity, and to move along the lightest matters, is water; which is made to flow with greater or less velocity and abundance over the *schlich* or pasty mud spread on a table of various inclination.

But as this operation always occasions, not only considerable expense, but a certain loss of metal, it is right to calculate what is the degree of richness below which washing is unprofitable; and on the other hand, what is the degree of purification of the *schlich* at which it is proper to stop, because too much metal would be lost comparatively with the expense of fusing a small additional quantity of *gangue*. There cannot, indeed, be any fixed rule in this respect, since the elements of these calculations vary for every work.

Before describing the different modes of washing, we must treat of the sifting or riddling, whose purpose, like that of the *labyrinth* succeeding the stamps, is to distribute and to separate the ores (which have not passed through the water stamps) in the order of the coarseness of grain. This operation is practised particularly upon the debris of the mine, and the rubbish produced in breaking the ores. These substances are put into a riddle, or species of round or square sieve, whose bottom is formed of a grating instead of a plate of metal pierced with holes. This riddle is plunged suddenly and repeatedly into a tub or cistern filled with water. This liquid enters through the bottom, raises up the mineral particles, separates them and keeps them suspended for an instant, after which they fall down in nearly the order of their specific gravities, and are thus classed with a certain degree of regularity. The sieve is sometimes dipped by the immediate effort of the washer; sometimes it is suspended to a swing which the workman moves; in order that the riddling may be rightly done, the sieve should receive but a single movement from below upwards; in this case the ore is separated from the *gangue*, and if there be different specific gravities, there is formed in the sieve as many distinct strata, which the workman can easily take out with a *spatula*, throwing the upper part away when it is too poor to be re-sifted. This operation by the hand-sieve, is called *riddling in the tub*, or riddling by deposit.

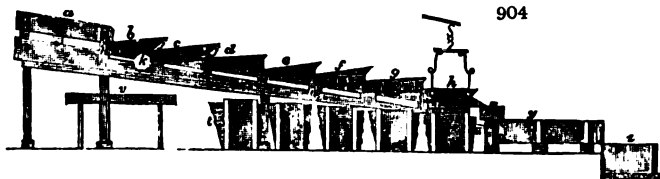
We may observe, that during the sifting, the particles which can pass across the holes of the bottom, fall into the tub and settle down there; whence they are afterwards gathered out, and exposed to washing when they are worth the trouble.

Sometimes, as at Poullaounen, the sieves are conical, and held by means of two handles by a workman; and instead of receiving a single movement, as in the preceding method, the sifter himself gives them a variety of dexterous movements in succession. His object is to separate the poor portions of the ore from the richer; in order to subject the former to the stamp mill.

Among the siftings and washings which ores are made to undergo, we must notice as

among the most useful and ingenious, those practised by *iron gratings*, called on the Continent *grilles anglaises*, and the *step-washings* of Hungary, *laveries à gradins*. These methods of freeing the ores from the pulverulent earthy matters, consist in placing them, at their out-put from the mine, upon gratings, and bringing over them a stream of water, which merely takes down through the bars the small fragments, but carries off the pulverulent portions. The latter are received in cisterns, where they are allowed to rest long enough to settle to the bottom. The washing by steps is an extension of the preceding plan. To form an idea, let us imagine a series of grates placed successively at different levels, so that the water, arriving on the highest, where the ore for washing lies, carries off a portion of it, through this first grate upon a second closer in its bars, thence to a third, &c., and finally into labyrinths or cisterns of deposition.

The *grilles anglaises* are similar to the *sleeping tables* used at Idria. The system of these *en gradins* is represented in *fig. 904*. There are 5 such systems in the works at Idria, for



the sorting of the small morsels of quicksilver ore, intended for the stamping mill. These fragments are but moderately rich in metal, and are picked up at random, of various sizes, from that of the fist to a grain of dust.

These ores are placed in the chest *a*, below the level of which 7 grates are distributed, so that the fragments which pass through the first *b*, proceed by an inclined conduit on to the second grate *c*, and so in succession. (See the conduits *l, o, p*). In front, and on a level with each of the gratings *b, c, d*, &c., a child is stationed on one of the floors, 1, 2, 3, to 7.

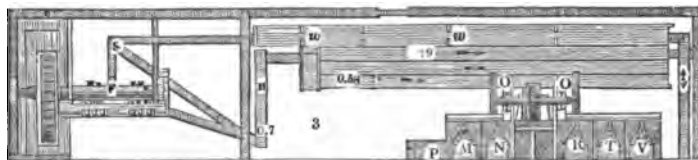
A current of water, which falls into the chest *a*, carries the fragments of ore upon the gratings. The pieces which remain upon the two gratings *b* and *c*, are thrown on the adjoining table *v*, where they undergo a sorting by hand; there the pieces are classified, 1. into gangue to be thrown away; 2. into ore for the stamp mill; 3. into ore to be sent directly to the furnace. The pieces which remain on each of the succeeding gratings, *d, e, f, g, h*, are deposited on those of the floors 3 to 7, in front of each. Before every one of these shelves a deposit-sieve is established, (see *t, u*), and the workmen in charge of it stand in one of the corresponding boxes, marked 8 to 12. The sieve is represented only in front of the chest *h*, for the sake of clearness.

Each of the workmen placed in 8, 9, 10, 11, 12, operates on the heap before him; the upper layer of the deposit formed in his sieve, is sent to the stamping house, and the inferior layer directly to the furnace.

As to the grains which, after traversing the five gratings, have arrived at the chest *x*, they are washed in the two chests *y*, which are analogous to the German chests to be presently described. The upper layer of what is deposited in *y* is sent to the furnace; the rest is treated anew on three tables of percussion, similar to the English brake-sieves, also to be presently described.

After several successive manipulations on these tables, an upper stratum of *schlich* is obtained fit for the furnace; an intermediate stratum, which is washed anew by the same process; and an inferior stratum, that is sent to the system of stamps, *fig. 905*.

905



A

This figure represents the general ground plan of a stamping and washing mill. The stamps *r* are composed of two batteries similar to *fig. 903*. The ore passes in succession under three pestles of cast iron, each of which is heavier the nearer it is to the sieve through which the sand or pounded matter escapes.

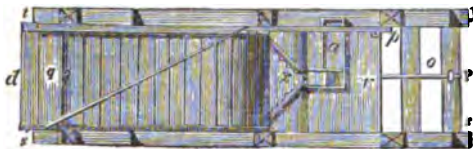
In the upper part of the figure we see issuing from the stamps, two conduits destined to receive the water and the metalliferous sand with which it is loaded. The first, marked *r, s, w*, is used only when a certain quality of ore is *stamped*, richer in metal than is

usually treated by means of the second conduit, the first being closed. The second conduit, or that employed for ordinary manipulation when the other is shut, is indicated by $r, 0\cdot7, s$; then by $0\cdot58$ and $0\cdot29$. These numbers express the depth of the corresponding portions of this conduit. From r to s , the conduit or water-course is divided into three portions much shallower, called the *rich conduit*, the *middle conduit*, and the *inferior*. Beyond the basin s , the conduit takes the name of labyrinth. There the muddy sediments of ore are deposited; being the finer the further they are from the stamps r . Darts indicate the direction of the stream in the labyrinth. On the *German chests*, placed at 3, the sand derived from the rich and middle conduits is treated, in order to obtain three distinct qualities of *schlich*, as already mentioned. r is a cloth-covered table, for treating the deposit of the German chests at 3. m, n are two sweep tables (*d balai*), for treating the ore collected in the lower conduit, which precedes the midmost of the three German chests. Upon the three similar tables u, v , are treated in like manner the muddy deposits of the labyrinth, which forms suite to three parallel German chests situated at 3, not shown for want of room in the figure, but connected in three rectangular zigzags with each other, as well as by a transverse branch to the points $0\cdot7$ and r . At the upper part of these five sweep tables, the materials which are to undergo washing are agitated in two boxes o, o , by small paddle-wheels.

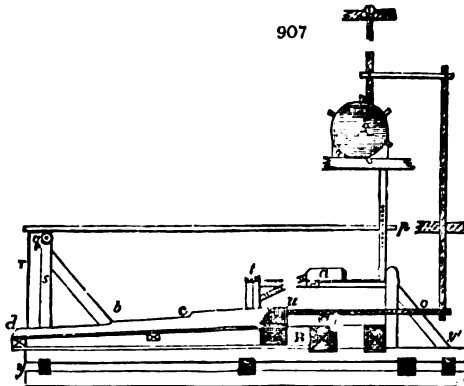
We shall now describe the *percussion-tables* used in the Hartz, for treating the sand of ore obtained from the conduits represented above.

Figs. 906, 907, and 908, exhibit a plan, a vertical section, and elevation, of one

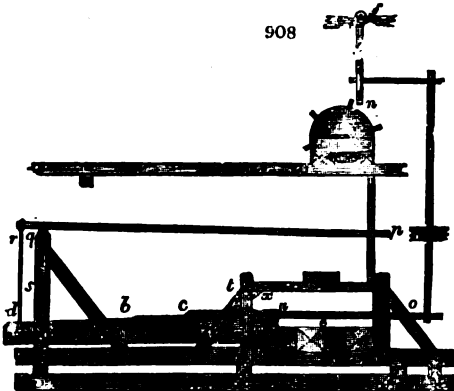
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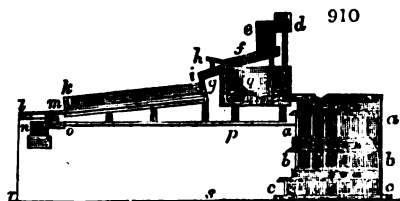
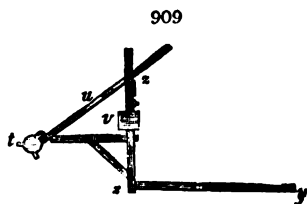
of these tables, taken in the direction of its length. The *arbor* or great shaft in prolongation from the stamps mill, is shown in section perpendicularly to its axis, at Δ . The *cams* or *wipers* are shown round its circumference, one of them having just acted on a .

These cams, by the revolution of the arbor, cause the alternating movements of a horizontal bar of wood o, u , which strikes at the point u against a table d, b, c, u . This table is suspended by two chains t , at its superior end, and by two rods at its lower end. After having been pushed by the piece o, u , it rebounds to strike against a block or bracket s . A lever p, q , serves to adjust the inclination of the movable table, the pivots q being points of suspension.

The ore-sand to be washed, is placed in the chest a , into which a current of water runs. The ore floated onwards by the water, is carried through a sieve on a sloping small table x , under which is concealed the higher end of the movable table d, b, c, u ; and it thence falls on this table, diffusing itself uniformly over its surface. The particles deposited on this table form an oblong *talus* (slope) upon it; the successive percussions that it receives, determine the weightier matters, and consequently those richest in metal, to accumulate towards its upper end at u . Now the workman by means of the lever p , raises the lower end d a little in order to preserve the same

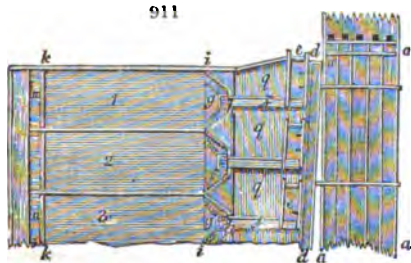
degree of inclination to the surface on which the deposit is strewed. According as the substances are swept along by the water, he is careful to remove them from the middle of the table towards the top, by means of a wooden roller. With this intent, he walks on the table *d b c u*, where the sandy sediment has sufficient consistence to bear him. When the table is abundantly charged with the washed ore, the deposit is divided into three bands or segments *d b*, *b c*, *c u*. Each of these bands is removed separately and thrown into the particular heap assigned to it. Every one of the heaps thus formed becomes afterwards the object of a separate manipulation on a percussion table, but always according to the same procedure. It is sufficient in general to pass twice over this table the matters contained in the heap, proceeding from the superior band *c u*, in order to obtain a pure *schlich*; but the heap proceeding from the intermediate belt *b c*, requires always a greater number of manipulations, and the lower band *d b* still more. These successive manipulations are so associated that eventually each heap furnishes pure *schlich*, which is obtained from the superior band *c u*. As to the lightest particles which the water sweeps away beyond the lower end of the percussion table, they fall into conduits; whence they are lifted to undergo a new manipulation.

Fig. 909. is a profile of a plan which has been advantageously substituted, in the Hartz, for that part of the preceding apparatus which causes the jolt of the piece *o u* against the table *d b c u*. By means of this plan, it is easy to vary, according to the circumstances of a manipulation always delicate, the force of percussion which a bar *x y*, ought to communicate by its extremity *y*. With this view, a slender piece of wood *u* is made to slide in an upright piece, *v x*, adjusted upon an axis at *v*. To the piece *u* a rod of iron is connected, by means of a hinge *z*; this rod is capable of entering more or less into a case or sheath in the middle of the piece *v x*, and of being stopped at the proper point, by a thumb-screw which presses against this piece. If it be wished to increase the force of percussion, we must lower the point *z*; if to diminish it, we must raise it. In the first case, the extremity of the piece *u*, advances so much further under



the cam of the driving shaft *t*; in the second, it goes so much less forwards; whereby the adjustment is produced.

Figs 910. and 911. represent a complete system of *sleeping tables, tables dormantes*;



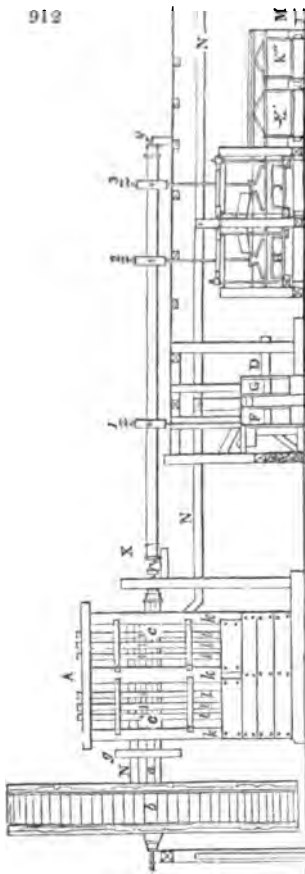
such as are mounted in Idria. Fig 911. is the plan, and fig. 910. a vertical section. The mercurial ores, reduced to a sand by stamps like those of fig. 905, pass into a series of conduits *a a*, *b b*, *c c*, which form three successive floors below the level of the floor of the works. The sand taken out of these conduits is thrown into the cells *q*; whence they are transferred into the trough *e*, and water is run upon them by turning two stopcocks for each trough. The sand thus diffused upon each table,

runs off with the water by a groove *f*, comes upon a sieve *h*, spreads itself upon the board *g*, and thence falls into the slanting chest, or sleeping table *i k*. The under surface *k* of this chest is pierced with holes, which may be stopped at pleasure with wooden plugs. There is a conduit *m*, at the lower end of each table, to catch the light particles carried off by the water out of the chest *i k*, through the holes properly opened, while the denser parts are deposited upon the bottom of this chest. A general conduit *n* passes across at the foot of all the chests *i k*; it receives the refuse of the washing operations.

Fig 912. is a set of stamping and washing works for the ores of argentiferous galena, as mounted at *Bockweise*, in the district of Zellerfeldt, in the Hartz.

▲ is the stamp mill and its subsidiary parts; among which are *a*, the driving or

main shaft; *b*, the overshot water-wheel; *c c*, six strong rings or hoops of cast iron, for receiving each a cam or tappet; *g*, the brake of the machine; *k, k, k*, the three standards of the stamps; *l, l, &c.* six pestles of pine wood, shod with lumps of cast iron. There are two chests, out of which the ore to be ground falls spontaneously into the two troughs of the stamps. Of late years, however, the ore is mostly supplied by hand; the watercourse terminates a short distance above the middle of the wheel *b*. There is a stream of water for the service of the stamps, and conduits proceeding from it, to lead the water into the two stamp troughs; the conduit of discharge is common to the two batteries or sets of stamps through which the water carries off the sand or stamped ore. There is a movable table of separation, mounted with two sieves. The sands pass immediately into the conduit placed upon a level with the floor, and separated into two compartments, the first of which empties its water into the second. There are two boards of separation, or tables, laid upon the ground, with a very slight slope of only 15 inches from their top to their bottom. Each of these boards is divided into four cases with edges; the whole being arranged so that it is possible, by means of a flood-gate or sluice, to cause the superfluous water of the case to pass into the following ones. Thus the work can go on without interruption, and alternately upon the two boards. There are winding canals in the labyrinth, *n, n, n*, in which are deposited the particles carried along by the water which has passed upon the boards. The depth of these canals gradually increases from 12 to 20 inches, to give a suitable descent for maintaining the water-flow. At *d*, two percussion tables are placed. *r o* are two German chests. *n j* are two percussion tables, which are driven by the cams *z z*, fixed upon the main shaft *x y*. *x x'* are two sloping sweep tables (*d balni*).

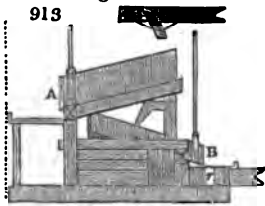


box, without any edge at the side next the chest, is placed, containing the ore to be washed. The water is allowed to fall upon the bolster in a thin sheet.

The *sleeping tables* have upright edges; they are from 4 to 5 yards long, nearly 2 yards wide, and have fully a yard of inclination.

The preceding tables are sometimes covered with cloth, particularly in treating ores that contain gold, on a supposition that the woollen or linen fibres would retain more surely the metallic particles; but this method appears on trial to merit no confidence, for it produces a very impure *schlick*.

Fig. 913. is a swing-sieve employed in the Hartz, for sifting the small fragments of the ore of argentiferous lead. Such an apparatus is usually set up in the outside of a stamp, and washing mill; its place being denoted by the letter *A*, in fig. 905. The two movable chests or boxes *A B*, of the sieve, are connected together, at their lower ends, with an upright rod, which terminates at one of the arms of a small balance beam, mounted between the driving shaft of the stamps and the sieve, perpendicularly to the length of both. The opposite arm of this beam carries another upright rod, which ears (cams or *mentonnets*), placed on purpose upon the driving shaft, may push down. During this movement the two lower ends *A, B*, are raised; and when the peg-cam of the shaft quits the rod which it had depressed, the swing chests fall by their own weight. Thus they



ment the two lower ends *A, B*, are raised; and when the peg-cam of the shaft quits the rod which it had depressed, the swing chests fall by their own weight. Thus they

are made to vibrate alternately upon their axes. The small ore is put into the upper part of the chest *A*, over which a stream of water falls from an adjoining conduit. The fragments which cannot pass through a cast-iron grid in the bottom of that chest, are sorted by hand upon a table in front of *A*, and they are classed by the workman, either among the ores to be stamped, whether dry or wet, or among the rubbish to be thrown away, or among the copper ores to be smelted by themselves. As to the small particles which fall through the grid upon the chest *B*, supplied also with a stream of water, they descend successively upon two other brass wire sieves, and also through the iron wire *r*, in the bottom of *B*.

In certain mines of the Hartz, tables called *à balais*, or *sweeping tables*, are employed. The whole of the process consists in letting flow, over the sloping table, in successive currents, water charged with the ore, which is deposited at a less or greater distance, as also pure water for the purpose of washing the deposited ore, afterwards carried off by means of this sweeping operation.

At the upper end of these *sweep-tables*, the matters for washing are agitated in a chest, by a small wheel with vanes, or flap-boards. The conduit of the muddy waters opens above a little table or shelf; the conduit of pure water, which adjoins the preceding, opens below it. At the lower part of each of these tables, there is a transverse slit, covered by a small door with hinges, opening outwardly, by falling back towards the foot of the table. The water spreading over the table, may at pleasure be let into this slit, by raising a bit of leather which is nailed to the table, so as to cover the small door when it is in the shut position; but when this is opened, the piece of leather then hangs down into it. Otherwise the water may be allowed to pass freely above the leather, when the door is shut. The same thing may be done with a similar opening placed above the conduit. By means of these two slits, two distinct qualities of *schlich* may be obtained, which are deposited into two distinct conduits or canals. The refuse of the operation is turned into another conduit, and afterwards into ulterior reservoirs, whence it is lifted out to undergo a new washing.

In the percussion tables, the water for washing the ores is sometimes spread in slender streamlets, sometimes in a full body, so as to let two cubic feet escape per minute. The number of shocks communicated per minute, varies from 15 to 36; and the table may be pushed out of its settled position at one time, three quarters of an inch, at another nearly 8 inches. The coarse ore-sand requires in general less water, and less slope of table, than the fine and pasty sand.

The *mechanical* operations which ores undergo, take place commonly at their out-put from the mine, and without any intermediate operation. Sometimes, however, the hardness of certain *gangues* (vein-stones), and of certain iron-ores, is diminished by subjecting them to calcination previously to the breaking and stamping processes.

When it is intended to wash certain ores, an operation founded on the difference of their specific gravities, it may happen that by slightly changing the chemical state of the substances that compose the ore, the earthy parts may become more easily separable, as also the other foreign matters. With this view, the ores of tin are subjected to a roasting, which by separating the arsenic, and oxidizing the copper which are intermixed, furnishes the means of obtaining, by the subsequent washing, an oxide of tin much purer than could be otherwise procured. In general, however, these are rare cases; so that the washing almost always immediately succeeds the picking and stamping; and the roasting comes next, when it needs to be employed.

The operation of roasting is in general executed by various processes, relatively to the nature of the ores, the quality of the fuel, and to the object in view. The greatest economy ought to be studied in the fuel, as well as the labour; two most important circumstances, on account of the great masses operated upon.

Three principal methods may be distinguished; 1. the roasting in a heap in the open air, the most simple of the whole; 2. the roasting executed between little walls, and which may be called *case-roasting* (*rost-stadeln*, in German); and 3. roasting in furnaces.

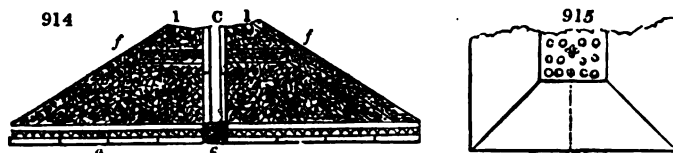
We may remark, as to the description about to be given of these different processes, that in the first two, the fuel is always in immediate contact with the ore to be roasted, whilst in furnaces, this contact may or may not take place.

1. The roasting in the open air, and in heaps more or less considerable, is practised upon iron ores, and such as are pyritous or bituminous. The operation consists in general in spreading over a plane area, often bottomed with beaten clay, billets of wood arranged like the bars of a gridiron, and sometimes laid crosswise over one another, so as to form a uniform flat bed. Sometimes wood charcoal is scattered in, so as to fill up the interstices, and to prevent the ore from falling between the other pieces of the fuel. Coal is also employed in moderately small lumps; and even occasionally, turf. The ore either simply broken into pieces, or even sometimes under the form of *schlich*, is piled up over the fuel; most usually alternate beds of fuel and ore are formed.

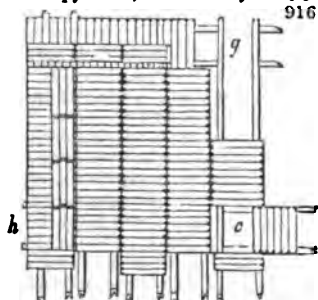
The fire, kindled in general at the lower part, but sometimes, however, at the middle chimney, spreads from spot to spot, putting the operation in train. The combustion must be so conducted as to be slow and suffocated, to prolong the ustulation, and let the whole mass be equally penetrated with heat. The means employed to direct the fire, are to cover outwardly with earth the portions where too much activity is displayed, and to pierce with holes or to give air to those where it is imperfectly developed. Rains, winds, variable seasons, and especially good primary arrangements of a calcination, have much influence on this process, which requires, besides, an almost incessant inspection at the beginning.

Nothing in general can be said as to the consumption of fuel, because it varies with its quality, as well as with the ores and the purpose in view. But it may be laid down as a good rule, to employ no more fuel than is strictly necessary for the kind of calcination in hand, and for supporting the combustion; for an excess of fuel would produce, besides an expense uselessly incurred, the inconvenience, at times very serious, of such a heat as may melt or vitrify the ores; a result entirely the reverse of a well-conducted ustulation.

Figs. 914, 915, 916. represent the roasting in mounds, as practised near Goalar in the



Hartz, and at Chessy in the department of the Rhone. *Fig. 914.* is a vertical section in the line *h c* of *figs. 915.* and *916.* In *fig. 915.* there is shown in plan, only a little more than one half of the quadrangular truncated pyramid, which constitutes the heap. *Fig. 916.* shows a little more than one fourth of a bed of wood, arranged at the bottom of the pyramid, as shown by *a a*, *fig. 914.*, and *c g h*, *fig. 916.* *c* is a wooden chimney,



formed within the heap of ore, at whose bottom *e* there is a little parcel of charcoal, *d d* are large lumps of ore distributed upon the wooden pile *a a*; *e e* are smaller fragments, to cover the larger; *f f* is rubbish and clay laid smoothly in a slope over the whole. *g*, *fig. 916.*, a passage for air left under the bed of billets; of which there is a similar one in each of the four sides of the base *a a*, so that two principal currents of air cross under the upright axis *c c*, of the truncated pyramid indicated in *fig. 914.*

The kindling is thrown in by the chimney *c*. The charcoal *c*, and the wood *a a*, take fire; the sulphureous ores *d e f* are heated to such a high temperature as to vaporize the sulphur. In the

Lower Hartz, a heap of this kind continues roasting during four months.

2. The second method. The difficulty of managing the fire in the roasting of substances containing little sulphur, with the greater difficulty of arranging and supporting in their place the *schlichs* to be roasted, and last of all, the necessity of giving successive fires to the same ores, or to inconsiderable quantities at a time, have led to the contrivance of surrounding the area on which the roasting takes place with three little walls, or with four, leaving a door in the one in front. This is what is called a *walled area*, and sometimes, improperly enough, a roasting furnace. Inside of these little walls, about 3 feet high, there are often vertical conduits or chimneys made to correspond with an opening on the ground level, in order to excite a draught of air in the adjacent parts. When the roasting is once set agoing, these chimneys can be opened or shut at their upper ends, according to the necessities of the process.

Several such furnaces are usually erected in connexion with each other by their lateral walls, and all terminated by a common wall, which forms their posterior part; sometimes they are covered with a shed supported partly by the back wall, built sufficiently high for this purpose. These dispositions are suitable for the roasting of *schlichs*, and in general of all matters which are to have several fires; a circumstance often indispensable to a due separation of the sulphur, arsenic, &c.

3. The furnaces employed for roasting the ores and the *matres* differ much, according

to the nature of the ores, and the size of the lumps. We shall content ourselves with referring to the principal forms.

When iron ores are to be roasted, which require but a simple calcination to disengage the combined water and carbonic acid, egg-shaped furnaces, similar to those in which limestone is burned in contact with fuel, may be conveniently employed; and they present the advantage of an operation which is continuous with a never-cooling apparatus. The analogy in the effects to be produced is so perfect, that the same furnace may be used for either object. Greater dimensions may, however, be given to those destined for the calcination of iron ores. But it must be remembered that this process is applicable only to ores broken into lumps, and not to ores in grains or powder.

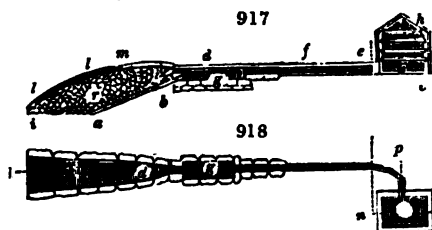
It has been attempted to employ the same method a little modified, for the roasting of ores of sulphuret of copper and pyrites, with the view of extracting a part of the sulphur. More or less success has ensued, but without ever surmounting all the obstacles arising from the great fusibility of the sulphuret of iron. For sometimes it runs into one mass, or at least into lumps agglutinated together in certain parts of the furnace, and the operation is either stopped altogether, or becomes more or less languid; the air not being able to penetrate into all the parts, the roasting becomes consequently imperfect. This inconvenience is even more serious than might at first sight appear; for, as the ill-roasted ores now contain too little sulphur to support their combustion, and as they sometimes fall into small fragments in the cooling, they cannot be passed again through the same furnace, and it becomes necessary to finish the roasting in a reverberatory hearth, which is much more expensive.

In the Pyrenees, the roasting of iron ores is executed in a circular furnace, so disposed that the fuel is contained and burned in a kind of interior oven, above which lie the pieces of ore to be calcined. Sometimes the vault of this oven which sustains the ore, is formed of bricks, leaving between them openings for the passage of the flame and the smoke, and the apparatus then resembles certain pottery kilns; at other times the vault is formed of large lumps of ore, carefully arranged as to the intervals requisite to be left for draught over the arch. The broken ore is then distributed above this arch, care being taken to place the larger pieces undermost. This process is simple in the construction of the furnace, and economical, as branches of trees, without value in the forests, may be employed in the roasting. See *Lime-kiln* figures.

In some other countries, the ores are roasted in furnaces very like those in which porcelain is baked; that is to say, the fuel is placed exteriorly to the body of the furnace in a kind of brick shafts, and the flame traverses the broken ore with which the furnace is filled. In such an apparatus the calcination is continuous.

When it is proposed to extract the sulphur from the iron pyrites, or from pyritous minerals, different furnaces may be employed, among which that used in Hungary deserves notice. It is a rectangular parallelepiped of four walls, each of them being perforated with holes and vertical conduits which lead into chambers of condensation, where the sulphur is collected. The ore placed between the four walls on billets of wood arranged as in *figs.* 914, 915, 916., for the great roastings in the open air, is calcined with the disengagement of much sulphur, which finds more facility in escaping by the lateral conduits in the walls, than up through the whole mass, or across the upper surface covered over with earth; whence it passes into the chambers of condensation. In this way upwards of a thousand tons of pyrites may be roasted at once, and a large quantity of sulphur obtained. See *Copper*.

Roasting of Pyrites. — *Figs.* 917, 918. represent a furnace which has been long em-



ployed at Fahlun in Sweden, and several other parts of that kingdom, for roasting iron pyrites in order to obtain sulphur. This apparatus was constructed by the celebrated Gahn. *Fig.* 917. is a vertical section, in the line *k d n o* of *fig.* 918., which is a plan of the furnace; the top being supposed to be taken off. In both figures the conduit may be imagined to be broken off at *e*; its entire length in a straight line is 43 feet

beyond the dotted line *e n*, before the bend, which is an extension of this conduit. Upon the slope *ab* of a hillock *abc*, lumps *r* of iron pyrites are piled upon the pieces of wood *ii* for roasting. A conduit *dfe* forms the continuation of the space denoted by *r*, which is covered by stone slabs so far as *f*; and from this point to the chamber *k* it is constructed in boards. At the beginning of this conduit, there is a recipient *g*. The chamber *k* is divided into five chambers by horizontal partitions, which permit the circulation of the

vapours from one compartment to another. The ores *r* being distributed upon the billets of wood *i*, whenever these are fairly kindled, they are covered with small ore, and then with rammed earth *ll*. Towards the point *m*, for a space of a foot square, the ores are covered with movable stone slabs, by means of which the fire may be regulated, by the displacement of one or more, as may be deemed necessary. The liquid sulphur runs into the recipient *g*, whence it is ladled out from time to time. The sublimed sulphur passes into the conduit *f e* and the chamber *h*, from which it is taken out, and washed with water, to free it from sulphuric acid with which it is somewhat impregnated; it is afterwards distilled in cast-iron retorts. The residuum of the pyrites is turned to account in Sweden, for the preparation of a common red colour much used as a pigment for wooden buildings.

The reverberatory furnace affords one of the best means of ustulation, where it is requisite to employ the simultaneous action of heat and atmospheric air to destroy certain combinations, and to decompose the sulphurets, arseniurets, &c. It is likewise evident that the facility thus offered of stirring the matters spread out on the sole, in order to renew the surfaces, of observing their appearances, of augmenting or diminishing the degree of heat, &c., promise a success much surer, a roasting far better executed, than by any other process. It is known, besides, that flame mingled with much undecomposed air issuing from the furnace, is highly oxidizing, and is very fit for burning away the sulphur, and oxidizing the metals. Finally, this is almost the only method of rightly roasting ores which are in a very fine powder. If it be not employed constantly and for every kind of ore, it is just because more economy is found in practising calcination in heaps, or on areas enclosed by walls; besides, in certain mines, a very great number of these furnaces, and many workmen, would be required to roast the considerable body of ores that must be daily smelted. Hence there would result from the construction of such apparatus and its maintenance a very notable outlay, which is saved in the other processes.

But in every case where it is desired to have a very perfect roasting, as for blende from which zinc is to be extracted, for sulphuret of antimony, &c., or even for ores reduced to a very fine powder, and destined for amalgamation, it is proper to perform the operation in a reverberatory furnace. When very fusible sulphurous ores are treated, the workman charged with the calcination must employ much care and experience, chiefly in the management of the fire. It will sometimes, indeed, happen, that the ore partially fuses; when it becomes necessary to withdraw the materials from the furnace, to let them cool and grind them anew, in order to recommence the operation. The construction of these furnaces demands no other attention than to give to the sole or laboratory the suitable size, and so to proportion to this the grate and the chimney that the heating may be effected with the greatest economy.

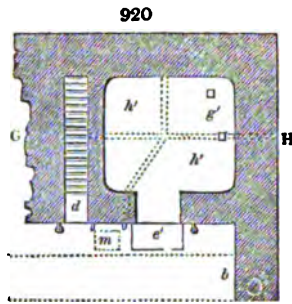
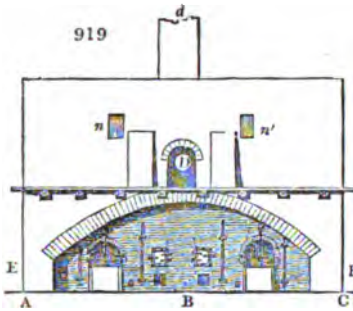
The reverberatory furnace is always employed to roast the ores of precious metals, and especially those for amalgamation; as the latter often contain arsenic, antimony, and other volatile substances, they must be disposed of in a peculiar manner.

The sole, usually very spacious, is divided into two parts, of which the one farthest off from the furnace is a little higher than the other. Above the vault there is a space or chamber in which the ore is deposited, and which communicates with the laboratory, by a vertical passage; which serves to allow the ore to be pushed down, when it is dried and a little heated. The flame and the smoke which escape from the sole or laboratory pass into condensing chambers, before entering into the chimney of draught, so as to deposit in them the oxide of arsenic and other substances. When the ore on the part of the sole farthest from the grate has suffered so much heat as to begin to be roasted, has become less fusible, and when the roasting of that in the nearer part of the sole is completed, the former is raked towards the fire-bridge, and its ustulation is finished by stirring it over frequently with a paddle, skilfully worked, through one of the doors left in the side for this purpose. The operation is considered to be finished when the vapours and the smell have almost wholly ceased; its duration depending obviously on the nature of the ores.

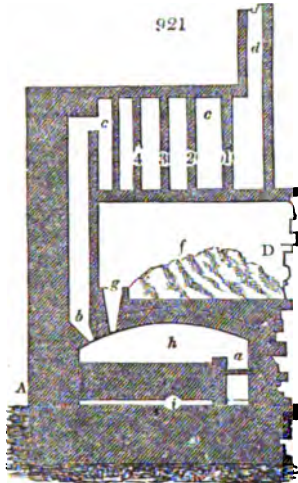
When this furnace is employed to roast very arsenical ores, as the tin ores of Schlackenwald in Bohemia, and at Ehrenfriedendorf in Saxony, the arsenical pyrites of Geyer (in Saxony), &c., the chambers of condensation for the arsenious acid are much more extensive than in the furnaces commonly used for roasting galena, copper, or even silver ores.

Figs. 919, 920, 921. represent a reverberatory furnace employed in the smelting works of Lautenthal, in the Hartz, for roasting the schlichs of lead ores, which contain much blende or sulphuret of zinc. In *fig. 919.* we see that the two parts *a b*, *b c*, are absolutely like, the two furnaces being built in one body of brickwork. *Fig. 920.* is the plan of the furnace *b c*, taken at the level *z r* of *fig. 919.* *Fig. 921.* is a vertical section of the similar furnace *a b*, taken in the prolongation of the line *o n* in *fig. 920.*

a is the fire-place of the furnace, its grate and ash-pit. *b* is the conduit of vaporization, which communicates with the chambers *c*; *c*, chambers into which the vaporized



substances are deposited; *d*, chimney for the escape of the smoke of the fire-place *a*, after it has gone through the space *b c e*; *e'*, is the charging door, with a hook hanging in front to rest the long iron rake upon, with which the materials are turned over; *f*, chamber containing a quantity of schlich destined for roasting; this chamber communicates with the vaulted corridor (gallery) *D*, seen in *fig. 919*; *g*, orifice through which the schlich is thrown into the furnace; *h*, area or hearth of the reverberatory furnace, of which the roof is certainly much too high; *i*, channels for the escape of the watery vapours; *k l*, front arcade, between which and the furnace, properly speaking, are the two orifices of the conduits, which terminate at the channels *m, m'*. *m* is the channel for carrying towards the chimney *d*, the vapours which escape by the door *e'*. *n* is a walled-up door, which is opened from time to time, to take out of the chambers *c, c'*, the substances that may be deposited in them.



At the smelting works of Lautenthal, in such a roasting furnace, from 6 to 9 quintals (cwts.) of schlich are treated at a time, and it is stirred frequently with an iron rake upon the altar *A*. The period of this operation is from 6 to 12 hours, according as the schlich may be more or less dry, more or less rich in lead, or more or less charged with blende.

When the latter substance is abundant, the process requires 12 hours, with about 60 cubic feet of cleft billets for fuel.

In such furnaces are roasted the cobalt ores of Schneeberg in Saxony, the tin ores of Schlackenwald in Bohemia, of Ehrenfriedersdorf in Saxony, and elsewhere; as also the arsenical pyrites at Geyer in Saxony. But there are poison towers and extensive condensing chambers attached in the latter case. See ARSENIC.

Figs. 922, 923, 224. represent the reverberatory furnace generally employed in the Hartz, in the district of Mansfeldt, Saxony, Hungary, &c., for the treatment of black copper, and for refining rose copper upon the great scale. An analogous furnace is used at Andreasberg for the liquefaction or purification of the mattes, and for workable lead when it is much loaded with arsenic

922

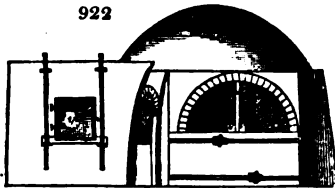
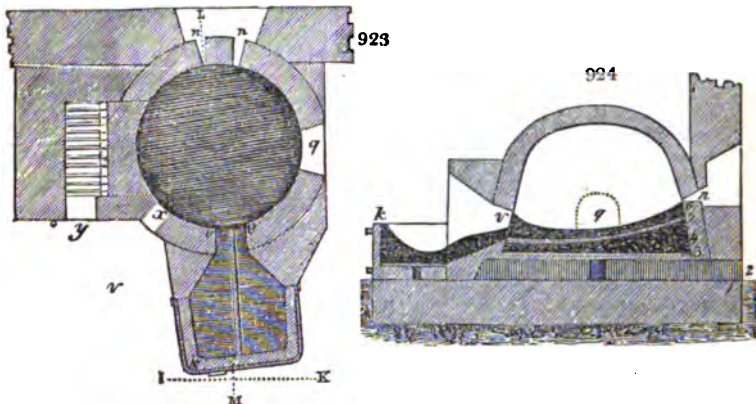
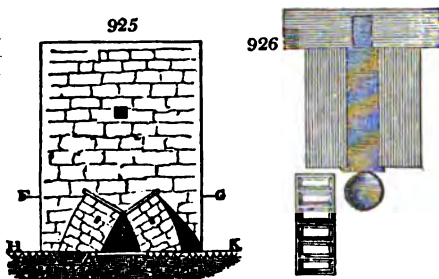


Fig. 922. presents the elevation of the furnace parallel to the line *x, x*, of the plan *fig. 923*; which plan is taken at the level of the tuyère *n*, of *fig. 924*; *fig. 924.* is a vertical section in the line *x, x*, *fig. 923*. *A* represents one of two basins of reception, brasqued with clay and charcoal; *n, n*, two tuyères, through which enters the blast of two pairs of bellows, like those shown at Cupellation of SILVER; *g*, door by which the matter to be melted is laid upon the sole of the furnace; *v, v*, two points where the sole is perforated, when necessary to run off the melted matter into either of the basins *A*; *x*, door through which the slags or cinders floating upon the sur-

face of the melted metal are raked out; *y*, door of the fire-place. The fuel is laid upon a grate above an ash-pit, and below the arch of a reverberatory which is contiguous to the dome or cap of the furnace properly so called. In the section, *fig. 924.*, the following parts may be noted: 1, 2, 3, mason-work of the foundation; 4, vapour channels



or conduits, for the escape of the humidity; 5, bed of clay; 6, brasque composed of clay and charcoal, which forms the concavity of the hearth.



Figs. 925, 926, 927., show the furnace employed for liquation in one of the principal smelting works of the Hartz. *Fig. 927.* exhibits the working area charged with the liquation cakes and charcoal, supported by sheets of wrought iron; being an image of the process in action. *Fig. 926.* is the plan, in the line *r, a*, of *fig. 925.*

A liquation cake is composed of—

Black copper holding at least 5 or 6 *loths* ($2\frac{1}{2}$ or 3 oz.) of silver per cwt., and weighing 90 to 96 lbs.

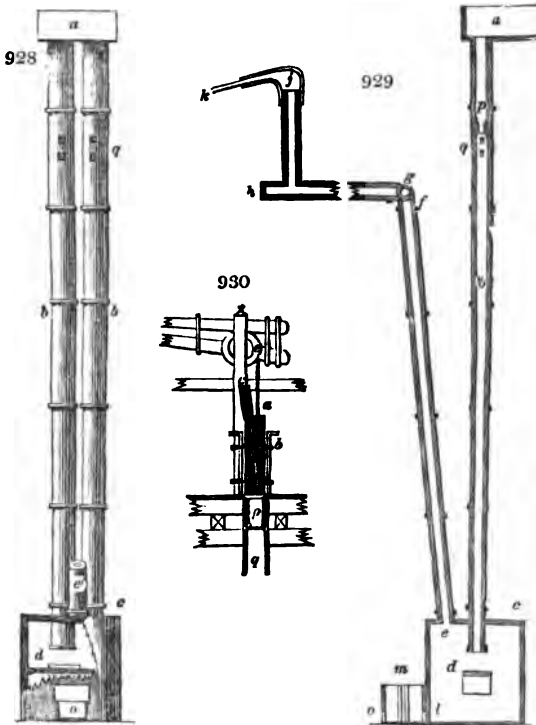
Lead obtained from litharge, 2 cwts. Litharge, $\frac{1}{4}$ cwt.

From 30 to 32 cakes are successively worked in one operation, which lasts about 5 hours; the furnace is brought into action, as usual, with the aid of slags; then a little litharge is added; when the lead begins to flow, the copper is introduced, and when the copper flows, lead is added, so that the mixture of the metals may be effected in the best way possible.

From 8 to 16 of these cakes (*pains*) are usually placed in the liquation furnace, *figs. 925, 926, 927.* The operation lasts 3 or 4 hours, in which time about $1\frac{1}{4}$ quintals of charcoal are consumed. The cakes are covered with burning charcoal, supported, as I have said, by the iron plates. The workable lead obtained flows off towards the basin in front of the furnace; whence it is laded out into moulds set alongside. See *fig. 926.* If the lead thus obtained be not sufficiently rich in silver to be worth cupellation, it is employed to form new liquation cakes. When it contains from 5 to 6 *loths* of silver per cwt., it is submitted to cupellation in the said smelting works. See *SILVER.*

The *trompe*, or water-blowing engine, *figs. 928, 929, 930.* *Fig. 928.* is the elevation; *fig. 929.* is a vertical section, made at right angles to the elevation. The machine is formed of two cylindrical pipes, the bodies of the *trompe* *b b*, set upright, called the funnels, which terminate above in a water cistern *a*, and below in a close basin under *c*, called the *sub* or

drum. The conical part *p* of the funnel has been called *strangwillon*, being *strangled*, as it were, in order that the water discharged into the body of the trompe shall not fill the



pipe in falling, but be divided into many streamlets. Below this *narrow part*, 8 holes *g g*, are perforated obliquely through the substance of the trompe, called the vent-holes or nostrils, for admitting the air, which the water carries with it in its descent. The air afterwards parts from the water, by dashing upon a cast-iron slab, placed in the *drum* upon the pedestal *d*. An aperture *l*, at the bottom of the drum, allows the water to flow away after its fall; but, to prevent the air from escaping along with it, the water as it issues is received in a chest *l m o n*, divided into two parts by a vertical side-plate between *m n*. By raising or lowering this plate, the water may be maintained at any desired level within the drum, so as to give the included air any determinate degree of pressure. The superfluous water then flows off by the hole *o*.

The air-pipe *e f*, fig. 929, is fitted to the upper part of the *drum*; it is divided, at the point *f*, into three tubes, of which the principal one is destined for the furnace of cupellation, whilst the other two *g g*, serve for different melting furnaces. Each of these tubes ends in a leather pocket, and an iron nose-pipe *k*, adjusted in the tuyère of the furnace. At Pesy, and in the whole of Savoy, a floodgate is fitted into the upper cistern *a*, to regulate the admission of water into the trompe; but in Carniola the funnel *p* is closed with a wooden plug, suspended to a cord, which goes round a pulley mounted upon a horizontal axis, as shown in fig. 930. By the plug *a* being raised more or less, merely the quantity of water required for the operation is admitted. The plug is pierced lengthwise with an oblique hole *c c*, in which the small tube *c* is inserted, with its top some way above the water level, through which air may be admitted into the heart of the column descending into the trompe *p g*.

The ordinary height of the trompe apparatus is about 26 or 27 feet to the upper level of the water cistern; its total length is 11 metres (36 feet 6 inches), and its width 2

feet, to give room for the drums. It is situated 10 metres (33 feet) from the melting furnace. This is the case at the smelting works of Jauerberg, in Upper Carniola.

OF THE ASSAY OF ORES.

Assays ought to occupy an important place in metallurgic instructions, and there is reason to believe that the knowledge of assaying is not sufficiently diffused, since its practice is so often neglected in smelting houses. Not only ought the assays of the ores under treatment, to be frequently repeated, because their nature is subject to vary; but the different products of the furnaces should be subjected to reiterated assays, at the several periods of the operations. When silver or gold ores are in question, the docimastic operations, then indispensable, exercise a salutary controul over the metallurgic processes, and afford a clear indication of the quantities of precious metal which they ought to produce.

By the title *Assays*, in a metallurgic point of view, is meant the method of ascertaining for any substance whatever, not only the presence and the nature of a metal, but its proportional quantity. Hence the operations which do not lead to a precise determination of the metal in question, are not to be arranged among the assays now under consideration. Experiments made with the blow-pipe, although capable of yielding most useful indications, are like the touchstone in regard to gold, and do not constitute genuine assays.

Three kinds of assays may be practised in different circumstances, and with more or less advantage upon different ores. 1. The mechanical assay; 2. the assay by the dry way; 3. the assay by the humid way.

1. *Of mechanical assays.*—These kinds of assays consist in the separation of the substances mechanically mixed in the ores, and are performed by a hand-washing, in a small trough of an oblong shape, called a *sebilla*. After pulverizing with more or less pains the matters to be assayed by this process, a determinate weight of them is put into this wooden bowl with a little water; and by means of certain movements and some precautions, to be learned only by practice, the lightest substances may be pretty exactly separated, namely, the earthy gangues from the denser matter or metallic particles, without losing any sensible portion of them. Thus a *schlich* of greater or less purity will be obtained, which may afford the means of judging by its quality of the richness of the assayed ores, and which may thereafter be subjected to assays of another kind, whereby the whole metal may be insulated.

Washing, as an assay, is practised on auriferous sands; on all ores from the *stamps*, and even on *schlichs* already washed upon the great scale, to appreciate more nicely the degree of purity they have acquired. The ores of tin in which the oxide is often disseminated in much earthy gangue, are well adapted to this species of assay, because the tin oxide is very dense. The mechanical assay may also be employed in reference to the ores whose metallic portion presents an uniform composition, provided it also possesses considerable specific gravity. Thus the ores of sulphuret of lead (galena) being susceptible of becoming almost pure sulphuret (within 1 or 2 per cent.) by mere washing, skilfully conducted, the richness of that ore in pure galena, and consequently in lead, may be at once concluded; since 120 of galena contain 104 of lead, and 16 of sulphur. The sulphuret of antimony mingled with its gangue may be subjected to the same mode of assay, and the result will be still more direct, since the crude antimony is brought into the market after being freed from its gangue by a simple fusion.

The assay by washing is also had recourse to for ascertaining if the *scoria* or other products of the furnaces contain some metallic grains which might be extracted from them by stamping and washing on the great scale; a process employed considerably with the *scoria* of tin and copper works.

Of assays by the dry way.—The assay by the dry way has for its object, to show the nature and proportion of the metals contained in a mineral substance. To make a good assay, however, it is indispensably necessary to know what is the metal associated with it, and even within certain limits, the quantity of the foreign bodies. Only one metal is commonly looked after; unless in the case of certain argentiferous ores. The mineralogical examination of the substances under treatment, is most commonly sufficient to afford data in these respects; but the assays may always be varied with different views, before stopping at a definite result; and in every instance, only such assays can be confided in as have been verified by a double operation.

This mode of assaying requires only a little experience, with a simple apparatus; and is of such a nature as to be practised currently in the smelting works. The air furnace and crucibles employed are described in all good elementary chemical books. These assays are usually performed with the addition of a flux to the ore, or some agent for separating the earthy from the metallic substances; and they possess a peculiar advantage relative to the smelting operations, because they offer many analogies between

results on the great scale and experiments on the small. This may even enable us often to deduce, from the manner in which the assay has succeeded with a certain flux, and at a certain degree of heat, valuable indications as to the treatment of the ore in the great way. See FURNACE.

In the smelting houses which purchase the ore, as in Germany, it is necessary to bestow much attention upon the assays, because they serve to regulate the quality and the price of the *schlichs* to be delivered. These assays are not by any means free from difficulties, especially when ores containing several useful metals are treated, and which are to be dosed or proportioned; ores, for example, including a notable quantity of lead, copper, and silver, mixed together.

In the central works of the Hartz, as well as in those of Saxony, the *schlichs* as delivered are subjected to docimastic assays, which are verified three times, and by three different persons, one of whom is engaged for the interests of the mining partners, another for that of the smelting house, and a third as arbiter in case of a difference. If the first two results of assaying differ by $\frac{1}{2}$ *loth* (or $\frac{1}{4}$ ounce) of silver per cwt. of *schlich*, the operations must be resumed; but this rarely happens. When out of the three assays, the one differs from the two others by no more than $\frac{1}{4}$ *loth* of silver per cwt., but by more in one, and by less in another, the mean result is adopted. As to the contents of the *schlich* in lead, the mean results of the assays must be taken. The differences allowed, are three pounds for the *schlich*, when it contains from 12 to 30 per cent. of lead, increasing to six pounds for *schlich*, when it contains less than 55 per cent. of that metal.

Assaying forms, in great establishments, an important object in reference to time and expense. Thus, in the single work of Franckenscharn, in the Hartz, no less than 300 assays have to be made in a threefold way, every Monday, without taking into account the several assays of the smelting products which take place every Thursday. Formerly fluxes more or less compound were employed for these purposes, and every assay cost about fifteen pence. At present all these assays are made more simply, by much cheaper methods, and cost a penny farthing each upon an average.

Of the assays by the humid way.—The assays by the humid way, not reducible to very simple processes, are true chemical analyses, which may in fact be applied with much advantage, either to ores, or to the products of the furnace; but which cannot be expected to be practised in smelting-houses, on account of the complication of apparatus and reagents they require. Moreover, an expert chemist is necessary to obtain results that can be depended on. The directors of smelting-houses, however, should never neglect any opportunities that may occur of submitting the materials operated upon, as well as their products, to a more thorough examination than the dry way alone can effect. One of the great advantages of similar researches is, to discover and appreciate the minute quantities of injurious substances which impair the malleability of the metals, which give them several bad qualities, about whose nature and cause, more or less error and uncertainty prevail. Chemical analysis, rightly applied to metallurgy, cannot fail to introduce remarkable improvements into the processes.—See the different metals, in their alphabetical places.

For assays in the dry way, both of stony and metallic minerals, the process of Dr. Abich deserves recommendation. It consists in mixing the pulverized mineral with 4 or 6 times its weight of carbonate of baryta in powder, fusing the mixture at a white heat, and then dissolving it, after it cools, in dilute muriatic acid. The most refractory minerals, even corundum, cyanite, staurolite, zircon, and felspar, yield readily to this treatment. This process may be employed with advantage upon poor refractory ores. The platinum crucible, into which the mixed materials are put for fusion, should be placed in a Hessian crucible and surrounded with good coke.

The manganese raised in England exceeds 2000 tons.

M. Heron de Villefosse inserted in the *Annales des Mines* for 1827 the following statistical view of the metallic products of France:—

| | Tons. |
|---|---------|
| Lead in pigs (<i>saucons</i>) | 103 |
| Litharge | 513 |
| Sulphuret of lead, ground galena (<i>alquifoux</i>) | 112 |
| Black copper | 164 |
| Antimony | 91 |
| Manganese | 765 |
| Crude cast iron | 25,606 |
| Bar iron | 127,643 |
| Steel | 3,500 |
| Silver in ingots | 1½ |

The total value of which is estimated at 80 millions of francs; or about 3,400,000 pounds sterling.

METALS; (*Métaux*, Fr.; *Metalle*, Germ.) are by far the most numerous class of undecomposed bodies in chemical arrangements. They amount to 43; of which 7 form, with oxygen, bodies possessed of alkaline properties: these are, 1. potassium; 2. sodium; 3. lithium; 4. barium; 5. strontium; 6. calcium; 7. magnesium; for even magnesia, the last and feeblest base, tinges turmeric brown, and red cabbage, green. The next five metals form, with oxygen, the earths proper; they are, 8. yttrium; 9. glucinum; 10. aluminum; 11. sironium; 12. thorium. The remaining 31 may be enumerated in alphabetical order, as they hardly admit of being grouped into subdivisions with any advantage. They are as follows: 13. antimony; 14. arsenic; 15. bismuth; 16. cadmium; 17. cerium; 18. chromium; 19. cobalt; 20. copper; 21. gold; 22. iridium; 23. iron; 24. lead; 25. manganese; 26. mercury; 27. molybdenum; 28. nickel; 29. osmium; 30. palladium; 31. platinum; 32. rhodium; 33. silver; 34. tantalum; 35. tellurium; 36. tin; 37. titanium; 38. tungstenium; 39. vanadium; 40. uranium; 41. zinc; 42. niobium; 43. pelopium.

1. They are all, more or less, remarkable for a peculiar lustre, called the metallic. This property of strongly reflecting light is connected with a certain state of aggregation of their particles, but is possessed, superficially at least, by mica, animal charcoal, selenium, polished indigo; — bodies not at all metallic.

2. The metals are excellent conductors of caloric, and most of them also of electricity, though probably not all. According to Despretz, they pass the power of conducting heat according to the following numbers: — Gold, 1000; platinum, 981; silver, 973; copper, 898; iron, 374; zinc, 363; tin, 304; lead, 179.6.

Bequerel gives the following table of metals, as to electrical conduction: —

Copper, 100; gold, 93.6; silver, 73.6; zinc, 28.5; platina, 16.4; iron, 15.8; tin, 15.5; lead, 8.3; mercury, 3.5; potassium, 1.33.

The metals which hardly, if at all, conduct electricity, are, sironium; aluminum; tantalum, in powder; and tellurium.

3. Metals are probably opaque; yet gold leaf, as observed by Newton, seems to transmit the green rays, for objects placed behind it in the sunbeam appear green. This phenomena has, however, been ascribed to the rays of light passing through an infinite number of minute fissures in the thinly hammered gold.

4. All metals are capable of combining with oxygen, but with affinities and in quantities extremely different. Potassium and sodium have the strongest affinity for it, arsenic and chromium the feeblest. Many metals become acids by a sufficient dose of oxygen, while, with a smaller dose, they constitute salifiable bases.

5. Metals combine with each other, forming a class of bodies called alloys, except when one of them is mercury, in which case the compound is styled an amalgam.

6. They combine with hydrogen into *hydrurets*; with carbon, into *carburets*; with sulphur, into *sulphurets*; with phosphorus, into *phosphurets*; with selenium, into *selenurets*; with boron, into *borurets* (*borides*?); with chlorine, into *chlorides*; with iodine, into *iodides*; with cyanogen, into *cyanides*; with silicon, into *silicides*; and with fluorine, into *fluorides*.

7. Metallic salts are definite compounds, mostly crystalline, of the metallic oxides with the acids. See HALOIDS.

METEORITES, (*Aerolithes*, Fr.), are stones of a peculiar aspect and composition, which have fallen from the air.

METER, GAS. Since the article *GAS* was printed I have had occasion to examine very carefully the construction, performance, and comparative merits of the four gas-meters most generally used in Great Britain, and have been led to conclude that the surmises concerning the correctness of the indications of several of them are but too well founded. The instruments on which my observations were made were all new, and just out of the hands of their respective patentees.

1. The meter of Mr. West is, no doubt, accurate while the water-line is rightly adjusted; but as I find that it will admit an extra pint of water, it may be rendered unjust towards the consumers of gas; and then if it receives a little more water by condensation of vapour, or by accident, its siphon gets filled, which causes the extinction of the lights.

2. The meter of Mr. Bottom has also several defects, and occasions nuisance by letting its overflow water trickle upon the floor.

3. The meter of Mr. Crossley may be made to err in its measurements fully 20 per cent. by dexterous repletion with water, and that in favour of the gas companies.

These three meters are furnished with the vertical float valve, so apt to rust and stick; they also allow gas to escape at the discharge plug, to the imminent risk of occasioning fire with ignorant or careless servants; and finally, they have the complex dial-plate indexes, so liable to misapprehension.

4. The meter of Mr. Edge. This instrument is quite exempt from all the above defects, and is equally delicate and just in its indications, being mounted with a lever valve of great mobility, and a new index, which any one who knows numbers cannot miscount. I have subjected this meter to every kind of test, and find that it cannot be made to give false indications, either by awkwardness or intention. Its inventor is therefore well entitled to the warm patronage both of the public and all gas companies who love fair dealing.

METHYLENE, a peculiar liquid compound of carbon and hydrogen, extracted from pyroxalic spirit, which is reckoned to be a bi-hydrate of *methylone*.

METRICAL MEASURES. The phrase "metrical measures" appears to an ordinary reader to savour of tautology. It is really not so, however, in the present instance; for the expression simply means a set of measures founded on the standard called the "metre," which was adopted by the government of France at the epoch of the first revolution. This standard is the ten-millionth part of the quadrant of the terrestrial meridian, and from the measurements and calculations which were made at that period on an arc of the meridian which extended from Barcelona to Dunkirk, it was reckoned to be 39-371 inches of the English standard yard, which contained 36 inches. Thus the French metre, which is longer than the English yard by $\frac{3}{4}$ inches, or more accurately by $\frac{3}{16}$ inches, is the standard of all the measures and weights of France. Its decimal multiples are successively denoted by the prefixes *deca*, *heca*, *chiles*, &c., which signify 10, 100, 1000, &c., times respectively; and its decimal submultiples or fractions successively by the prefixes *deci*, *centi*, *milli*, &c., which signify $\frac{1}{10}$, $\frac{1}{100}$, $\frac{1}{1000}$, &c., parts respectively. The metre itself was made the unit of lineal measure and itinerary distances.

The *deca metre* squared, which was called the *are*, and consequently contains 100 square metres, was made the unit of superficial or land measure; its centesimal multiple *hectare* contains 10,000 square metres, and its centesimal submultiple *centiare* 1 square metre.

The *decimetre* cubed, which was called the *litre*, and therefore contained a thousandth part of the metre cubed, was made the unit of capacity for liquids; its decimal multiple *decilitre* contains 10 cubic decimetres, and its decimal submultiple *decilitre* one-tenth part of the cubic decimetre. The litre and its successive multiples *decilitre*, *hectolitre*, &c., were also made the measures for dry goods, such as corn, &c. The cubic metre itself was made the unit of solid measures, and called the *stere*; its decimal submultiple the *decistere* containing a tenth part of the cubic metre. The weight of a cubic *centimetre* of distilled water at the maximum density was called the *gramme*, and made the unit of all measures of weight. This unit was found by careful experiments to be equivalent to 15-434 grains of English troy weight; hence the kilogramme, the usual unit for commercial purposes in France, weighs a trifle more than $\frac{2}{3}$ pounds of English avoirdupois weight. From the decimal relations which subsist among these different weights and measures it plainly appears that the *kilogramme* is equal to the weight of a cubic *decimetre* of water, or of a *litre* of the same liquid at the maximum density. The capacity of the *litre* is therefore a trifle more than 61 English cubic inches, or about two-ninths of an English gallon diminished by a hundredth part of the two-ninths.

MICA is a finely foliated mineral, of a pearly metallic lustre. It is harder than gypsum, but not so hard as calc-spar; flexible and elastic; spec. grav. 2-65. It is an ingredient of granite and gneiss. The large sheets of mica exposed for sale in London, are mostly brought from Siberia. They are used, instead of glass, to enclose the fire, without concealing the flame, in certain stoves.

The mica of Fahln, analysed by Rose, afforded silica, 46-23; alumina, 34-52; peroxide of iron, 6-04; potash, 8-22; magnesia, with oxide of manganese, 2-11; fluoric acid, 1-09; water, 0-96.

MICROCOSMIC SALT; a term given to a salt extracted from human urine, because man was regarded by the alchemists as a miniature of the world, or the microcosm. It is a phosphate of soda and ammonia; and is now prepared by mixing equivalent proportions of phosphate of soda and phosphate of ammonia, each in solution, evaporating and crystallizing the mixture. A small excess of ammonia aids the crystallization.

MILK; (*Lait*, Fr.; *Milch*, Germ.) owes its whiteness and opacity to an emulsion composed of the caseous matter and butter, with sugar of milk, extractive matters, salts, and free lactic acid; the latter of which causes fresh milk to reddens litmus paper. Milk, in general, contains from 10 to 12 per cent. of solid matter, on being evaporated to dryness by a steam heat. The mean specific gravity of cows' milk is 1-030, but it is less if the milk be rich in cream. The specific gravity of the skimmed milk is 1-035; and of the cream is 1-0244. 100 parts of creamed milk, contain —

| | | | | | |
|---|---|---|---|---|--------|
| Caseous matter, containing some butter, | - | - | - | - | 2-600 |
| Sugar of milk | - | - | - | - | 3-500 |
| Alcoholic extract, lactic acid, and lactates | - | - | - | - | 0-600 |
| Salts; muriate and phosphate of potash, and phosphate of lime | - | - | - | - | 0-490 |
| Water | - | - | - | - | 92-875 |

Cream consists of,

| | | | | | |
|--|---|---|---|---|------|
| Butter separated by churning | - | - | - | - | 4-5 |
| Caseous matter precipitated by the coagulation of the milk of the butter | - | - | - | - | 3-5 |
| Butter-milk | - | - | - | - | 92-0 |

When milk contained in wire-corked bottles is heated to the boiling point in a water-bath, the oxygen of the included small portion of air under the cork seems to be carbonated, and the milk will afterwards keep fresh, it is said, for a year or two; as green gooseberries and peas do by the same treatment.

Milk has been adulterated with a solution of potato starch, from which it derives a creamy consistence. This fraud may be detected by pouring a few drops of iodine water into it, which immediately causes it to assume a blue or purple tint. Emulsion of sweet almonds, with which the milk at Paris has been adulterated, may be readily detected by the taste.

MILL ARCHITECTURE, is a science of recent origin, which even at this day is little understood beyond the factory precincts. It had been ably begun by Mr. Watt, but till it fell into the hands of Messrs. Fairbairn and Lillie, eminent engineers of Manchester, it was too subject to the whims of the several individuals, often utterly ignorant of statics or dynamics, or the laws of equilibrium and impulse, who had capital to lay out in building a mill. Each had his own set of caprices and prejudices, which he sought to embody in his edifice, little aware how much the different orders of machines depended for the productiveness and precision of their performance on the right magnitudes, proportions, and adjustments of the main shafting and wheel gearing. These are in fact the grand nerves and arteries which transmit vitality and volition, so to speak, with due steadiness, delicacy, and speed, to the automatic organs. Hence, if they be ill-made or ill-distributed, nothing can go well.

Mr. Fairbairn has for many years entered largely into the line of a factory architect, for which his three-fold great workshops are admirably adapted. The capitalist has merely to state the extent of his resources, the nature of his manufacture, its intended site and facilities of position in reference to water or coal, when he will be furnished with designs, estimates, and offers on the most economical terms consistent with excellence, according to a plan combining elegance of external aspect with solidity, convenience, and refinement in the internal structure. As engineer, he becomes responsible for the masonry, carpentry, and other work of the building, for the erection of a sufficient power, whether of a steam-engine or water-wheel, to drive every machine it is to contain, and for the mounting of all the shafts and great wheels by which the power of the first mover is distributed.

The recent innovations in proportioning the sizes, regulating the connections, and adjusting the movements of the system of shaft gearing, form a fine feature in the philosophy of manufactures. Thus not only an improvement has been made in the regularity of impulsion, but a considerable increase of power from the same prime-mover has been obtained; amounting in some cases, of old mills remounted by Messrs. Fairbairn and Lillie, to fully 20 per cent. The durability of shafts so exquisitely turned and polished is another great advantage. The spinning factory of Messrs. Ashworth, at Egerton, which has been at work for several years, exhibits an excellent pattern of the engineering just described: for it has some subordinate shafts, hardly thicker than the human wrist, which convey the power of ten horses, and revolve with great speed, without the slightest noise or vibration. The prime-mover of the whole is a gigantic water-wheel of 60 feet diameter, and 100 horses' power. I have frequently been at a loss in walking through several of the mill-wright factories, to know whether the polished shafts that drive the automatic lathes and planing machines, were at rest or in motion, so truly and silently did they revolve.

The method of increased velocities in the driving arms of shafts of factories is undoubtedly one of the most remarkable improvements in practical dynamics. It diminishes greatly the inertia of the mass to be moved, by giving to much lighter shafts and wheels the same momentum; and it permits the pulleys or drums, which immediately impel the machines by straps, to be reduced to a size much nearer to that of the steam pulleys fixed on the main axes of these machines. About thirty years ago the velocities of the main shafts proceeding from the moving power, whether of steam or water, amounted to no more than from 30 to 40 revolutions per minute; and of the smaller and remoter shafts, to only 40 or 50. At the same period the drums were heavy tubs,

and from 30 to upwards of 60 inches in diameter. This improved system is under deep obligations for its actual state of perfection to the above-named engineers, though it had commenced, as we have stated, before their time. In the mills mounted by these gentlemen, it is interesting to see slender shafts, like small sinewy arms, rapidly transmitting vast power through all the ramifications of a great factory.

The following details will place this matter in the clearest light:—A mill propelled by a steam-engine of 50 horses' power, was formerly geared with shafts, having an average transverse section of 36 square inches, or varying in size from 4 to 8 inches square. An engine of like power at the present day will, in consequence of the increased velocities above described, work with cylindrical shafts not exceeding $5\frac{1}{2}$, and often only 3 inches in diameter; possessing, therefore, an average area of only 15 square inches, instead of 36. The horizontal shafts that run under the ceilings of the different working-rooms are 2 inches, and seldom exceed $2\frac{1}{4}$ in diameter. Hence the mass of gearing has been reduced fully one-half. But the shafts now make from 120 to 150 revolutions in a minute, and occasionally, as where throistles are turned, so many as 200 in the same time. Thus we see the requisite momentum is gained with a light shaft, while the friction is proportionally diminished, and the driving-drum revolves with a velocity in accordance with the accelerated pace of the modern machines. The several speeds are given in discussing their respective subjects.

The philosophy of manufactures investigates, in the next place, the most economical and energetic modes of applying the motive force to the various working organs; the carding engines, the drawing heads, the roving frames, the throistles, the mules, the power-looms, the dressing-machines, &c.

The British capitalist is vigorously seconded by the British engineer, and need not, like the continental adventurer, leave his funds long dormant, after an opportunity of placing them profitably in factory enterprise occurs. Fairbairn's millwright establishment in Manchester turns out from 300 to 400 yards of shaft-gearing every week, finely finished at a very moderate price, because almost every tool is now more or less automatic, and performs its work more cheaply and with greater precision than the hand could possibly do. Where many counterparts or similar pieces enter into spinning apparatus, they are all made so perfectly identical in form and size, by the self-acting tools, such as the planing and key-groove cutting machines, that any one of them will at once fit into the position of any of its fellows in the general frame.

MILL-STONE, or **BUHR-STONE**. This interesting form of silica, which occurs in great masses, has a texture essentially cellular, the cells being irregular in number, shape, and size, and are often crossed by thin plates, or coarse fibres of silex. The buhr-stone has a straight fracture, but it is not so brittle as flint, though its hardness is nearly the same. It is feebly translucent; its colours are pale and dead, of a whitish, grayish, or yellowish cast, sometimes with a tinge of blue.

The Buhr-stones usually occur in beds, which are sometimes continuous, and at others interrupted. These beds are placed amid deposits of sand, or argillaceous and ferruginous marls, which penetrate between them, filling their fissures and honeycomb cavities. Buhr-stones constitute a very rare geological formation, being found in abundance only in the mineral basin of Paris, and a few adjoining districts. Its place of superposition is well ascertained: it forms a part of the lacustrine, or fresh-water formation, which, in the locality alluded to, lies above the fossil-bone gypsum, and the stratum of sand and marine sandstone which cover it. Buhr-stone constitutes, therefore, the uppermost solid stratum of the crust of the globe; for above it there is nothing but alluvial soil, or diluvial gravel, sand, and loam.

Buhr-stones sometimes contain no organic forms, at others they seem as if stuffed full of fresh-water shells, or land shells and vegetables of inland growth. There is no exception known to this arrangement; but the shells have assumed a siliceous nature, and their cavities are often bedecked with crystals of quartz. The best buhr-stones for grinding corn have about an equal proportion of solid matter and of vacant space. The finest quarry of them is upon the high ground, near *La-Perth-sous-Jouarre*. The stones are quarried in the open air, and are cut out in cylinders from one to two yards in diameter, by a series of iron and wooden wedges, gradually but equally inserted. The pieces of buhr-stones are afterwards cut into parallelipeds, called *panes*, which are bound with iron hoops into large millstones. These pieces are exported chiefly to England and America. Good millstones of a bluish white colour, with a regular proportion of cells, when six feet and a half in diameter, fetch 1200 francs a-piece, or 48*l.* sterling. A coarse conglomerate sandstone or breccia is, in some cases, used as a substitute for buhr-stones; but it is a poor one.

MINERAL WATERS. See **SODA WATER**, and **WATERS, MINERAL**.

MINES. (*Bergwerke*, Germ.) Amidst the variety of bodies apparently infinite, which compose the crust of the globe, geologists have demonstrated the prevalence of a few

general systems of rocks, to which they have given the name of *formations* or *deposits*. A large proportion of these mineral systems consists of parallel planes, whose length and breadth greatly exceed their thickness; on which account they are called stratified rocks; others occur in very thick blocks, without any parallel stratification, or horizontal seams of considerable extent.

The stratiform deposits are subdivided into two great classes; the primary and the secondary. The former seem to have been called into existence before the creation of organic matter, because they contain no exuvius of vegetable or animal beings; while the latter are more or less interspersed, and sometimes replete with organic remains. The primary strata are characterised, moreover, by the nearly vertical or highly inclined position of their planes; the secondary lie for the most part in a nearly horizontal position.

Where the primitive mountains graduate down into the plains, rocks of an intermediate character appear, which, though possessing a nearly vertical position, contain a few vestiges of animal beings, especially shells. These have been called *transition*, to indicate their being the passing links between the first and second systems of ancient deposits; they are distinguished by the fractured and cemented texture of their planes, for which reason they are sometimes called conglomerate.

Between these and the truly secondary rocks, another very valuable series is interposed in certain districts of the globe; namely, the coal-measures, the paramount formation of Great Britain. The coal strata are disposed in a basin-form, and alternate with parallel beds of sandstone, slate-clay, iron-stone, and occasionally limestone. Some geologists have called the coal-measures the medial formation.

In every mineral plane, the inclination and direction are to be noted; the former being the angle which it forms with the horizon, the latter the point of the azimuth or horizon, towards which it dips, as west, north-east, south, &c. The direction of the bed is that of a horizontal line drawn in its plane; and which is also denoted by the point of the compass. Since the lines of direction and inclination are at right angles to each other, the first may always be inferred from the second; for when a stratum is said to dip to the east or west, this implies that its direction is north and south.

The smaller sinuities of the bed are not taken into account, just as the windings of a river are neglected in stating the line of its course.

Masses are mineral deposits, not extensively spread in parallel planes, but irregular heaps, rounded or oval, enveloped in whole or in a great measure by rocks of a different kind. Lenticular masses being frequently placed between two horizontal or inclined strata, have been sometimes supposed to be stratiform themselves, and have been accordingly denominated by the Germans *liegende stocks*, *lying heaps* or *blocks*.

The orbicular masses often occur in the interior of unstratified mountains, or in the bosom of one bed.

Nests, concretions, nodules, are small masses found in the middle of strata; the first being commonly in a friable state; the second often kidney-shaped, or tuberous; the third nearly round, and encrusted, like the kernel of an almond.

Lodes, or large veins, are flattened masses, with their opposite surfaces not parallel, which consequently terminate like a wedge, at a greater or less distance, and do not run parallel with the rocky strata in which they lie, but cross them in a direction not far from the perpendicular; often traversing several different mineral planes. The *lodes* are sometimes deranged in their course, so as to pursue for a little way the space between two contiguous strata; at other times they divide into several branches. The matter which fills the lodes is for the most part entirely different from the rocks they pass through, or at least it possesses peculiar features.

This mode of existence, exhibited by several mineral substances, but which has been long known with regard to metallic ores, suggests the idea of clefts or rents having been made in the stratum posterior to its consolidation, and of the vacancies having been filled with foreign matter, either immediately or after a certain interval. There can be no doubt as to the justness of the first part of the proposition, for there may be observed round many lodes undeniable proofs of the movement or dislocation of the rock; for example, upon each side of the rent, the same strata are no longer situated in the same plane as before, but make greater or smaller angles with it; or the stratum upon one side of the lode is raised considerably above, or depressed considerably below, its counterpart upon the other side. With regard to the manner in which the rent has been filled, different opinions may be entertained. In the lodes which are widest near the surface of the ground, and graduate into a thin wedge below, the foreign matter would seem to have been introduced as into a funnel at the top, and to have carried along with it in its fluid state portions of rounded gravel and organic remains. In other cases, other conceptions seem to be more probable; since many lodes are largest at their under part, and become progressively narrower as they approach the surface; from which circumstance, it has been inferred that the rent has been caused by an

expansive force acting from within the earth, and that the foreign matter, having been injected in a fluid state, has afterwards slowly crystallized. This hypothesis accounts much better than the other for most of the phenomena observable in mineral veins, for the alterations of the rock at their sides, for the crystallization of the different substances interspersed in them, for the cavities bestudded with little crystals, and for many minute peculiarities. Thus, the large crystals of certain substances which line the walls of hollow veins, have sometimes their under surfaces besprinkled with small crystals of sulphurets, arseniurets, &c., while their upper surfaces are quite smooth; suggesting the idea of a slow sublimation of these volatile matters from below, by the residual heat, and their condensation upon the under faces of the crystalline bodies, already cooled. This phenomenon affords a strong indication of the igneous origin of metalliferous veins.

In the lodes, the principal matters which fill them are to be distinguished from the accessory substances; the latter being distributed irregularly, amidst the mass of the first, in crystals, nodules, grains, seams, &c. The non-metalliferous exterior portion, which is often the largest, is called *gangue*, from the German *gang*, vein. The position of a vein is denoted, like that of the strata, by the angle of inclination, and the point of the horizon towards which they dip, whence the direction is deduced.

Veins, are merely small lodes, which sometimes traverse the great ones, ramifying in various directions, and in different degrees of tenuity.

A metalliferous substance is said to be *disseminated*, when it is dispersed in crystals, spangles, scales, globules, &c., through a large mineral mass.

Certain ores which contain the metals most indispensable to human necessities, have been treasured up by the Creator in very bountiful deposits; constituting either great masses in rocks of different kinds, or distributed in lodes, veins, nests, concretions, or beds with stony and earthy admixtures; the whole of which become the objects of mineral exploration. These precious stores occur in different stages of the geological formations; but their main portion, after having existed abundantly in the several orders of the primary strata, suddenly cease to be found towards the middle of the secondary. Iron ores are the only ones which continue among the more modern deposits, even so high as the beds immediately beneath the chalk, when they also disappear, or exist merely as colouring matters of the tertiary earthy beds.

The strata of gneiss and mica-slate constitute in Europe the grand metallic domain. There is hardly any kind of ore which does not occur there in sufficient abundance to become the object of mining operations, and many are found no where else. The transition rocks and the lower part of the secondary ones, are not so rich, neither do they contain the same variety of ores. But this order of things, which is presented by Great Britain, Germany, France, Sweden, and Norway, is far from forming a general law; since in equinoxial America the gneiss is but little metalliferous; while the superior strata, such as the clay-schists, the sienitic porphyries, the limestones, which complete the transition series, as also several secondary deposits, include the greater portion of the immense mineral wealth of that region of the globe.

All the substances of which the ordinary metals form the basis, are not equally abundant in nature; a great proportion of the numerous mineral species which figure in our classifications, are mere varieties scattered up and down in the cavities of the great masses or lodes. The workable ores are few in number, being mostly sulphurets, some oxides, and carbonates. These occasionally form of themselves very large masses, but more frequently they are blended with lumps of quartz felspar, and carbonate of lime, which form the main body of the deposit; as happens always in proper lodes. The ores in that case are arranged in small layers parallel to the strata of the formation, or in small veins which traverse the rock in all directions, or in nests or concretions stationed irregularly, or finally disseminated in hardly visible particles. These deposits sometimes contain apparently only one species of ore, sometimes several, which must be mined together, as they seem to be of contemporaneous formation; whilst, in other cases, they are separable, having been probably formed at different epochs. In treating of the several metals in their alphabetical order, I have taken care to describe their peculiar geological positions, and the rocks which accompany or mineralize them.

In mining, as in architecture, the best method of imparting instruction is to display the master-pieces of the respective arts, which speak clearly to the mind through the medium of the eye. It is not so easy, however, to represent at once the general effect of a mine, as it is of an edifice; because there is no point of sight from which the former can be sketched at once, like the latter. The subterraneous structures certainly afford some of the finest examples of the useful labours of man, continued for ages, under the guidance of science and ingenuity; but, however curious, beautiful, and grand in themselves, they cannot become objects of a panoramic view. It is only by the lights of geometry and geology that mines can be contemplated and surveyed, either as a whole or in their details; and, therefore, these marvellous subterranean regions, in which roads are cut

many hundred miles long, are altogether unknown or disregarded by men of the world. Should any of them, perchance, from curiosity or interest, descend into these dark recesses of the earth, they are prepared to discover only a few insulated objects, which they may think strange or possibly hideous; but they cannot recognize either the symmetrical disposition of mineral bodies, or the laws which govern geological phenomena, and serve as sure guides to the skillful miner in his adventurous search. It is by exact plans and sections of subterraneous workings, that a knowledge of the nature, extent, and distribution of mineral wealth, can be acquired.

931. *A general view of mining operations.*



As there is no country in the world so truly rich and powerful, by virtue of its mineral stores, as Great Britain, so there are no people who ought to take a deeper interest in their scientific illustration. I have endeavoured in the present article to collect from the most authentic sources the most interesting and instructive examples of mining operations.

To the magnificent work of Ville-Fosse, *Sur la Richesse Minerale*, no longer on sale, I have to acknowledge weighty obligations; many of the figures being copied from his great Atlas.

Lodes or mineral veins are usually distinguished by English miners into at least four species. 1. The rake vein. 2. The pipe vein. 3. The flat or dilated vein; and 4. The interlaced mass (*stock-werke*), indicating the union of a multitude of small veins mixed in every possible direction with each other, and with the rock.

1. The *rake* vein is a perpendicular mineral fissure; and is the form best known among practical miners. It commonly runs in a straight line, beginning at the superficies of the strata, and cutting them downwards, generally further than can be reached. This vein sometimes stands quite perpendicular; but it more usually inclines or hangs over at a greater or smaller angle, or slope, which is called by the miners the *hade* or *hading* of the vein. The line of direction in which the fissure runs, is called the *bearing* of the vein.

2. The *pipe* vein resembles in many respects a huge irregular cavern, pushing forward into the body of the earth in a sloping direction, under various inclinations, from an angle of a few degrees to the horizon, to a dip of 45°, or more. The pipe does not in general cut the strata across like the rake vein, but insinuates itself between them; so that if the plane of the strata be nearly horizontal, the bearing of the pipe vein will be conformable; but if the strata stand up at a high angle, the pipe shoots down nearly headlong like a shaft. Some pipes are very wide and high, others are very low and narrow, sometimes not larger than a common mine or drift.

3. The *flat* or *dilated* vein, is a space or opening between two strata or beds of stone, the one of which lies above, and the other below this vein, like a stratum of coal

between its roof and pavement; so that the vein and the strata are placed in the same plane of inclination. These veins are subject, like coal, to be interrupted, broken, and thrown up or down by slips, dykes, or other interruptions of the regular strata. In the case of a metallic vein, a slip often increases the chance of finding more treasure. Such veins do not preserve the parallelism of their beds, characteristic of coal seams; but vary excessively in thickness within a moderate space. Flat veins occur frequently in limestone, either in a horizontal or declining direction. The flat or strata veins open and close, as the rake veins also do.

4. The interlaced mass has been already defined.

To these may be added the *accumulated* vein, or irregular mass (*butzenwerke*), a great deposit placed without any order in the bosom of the rocks, apparently filling up cavernous spaces.

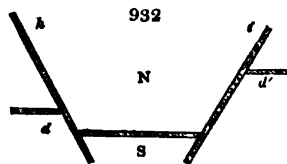
The interlaced masses are more frequent in primitive formations, than in the others; and tin is the ore which most commonly affects this locality. See figure of TIN mine.

The study of the mineral substances, called *gangues* or vein-stones, which usually accompany the different ores, is indispensable in the investigation and working of mines. These *gangues*, such as quartz, calcareous spar, fluor spar, heavy spar, &c., and a great number of other substances, although of little or no value in themselves, become of great consequence to the miner, either by pointing out by their presence that of certain useful minerals, or by characterising in their several associations, different deposits of ores of which it may be possible to follow the traces, and to discriminate the relations, of a complicated kind, provided we observe assiduously the accompanying *gangues*.

Mineral veins are subject to derangements in their course, which are called shifts or faults. Thus, when a transverse vein throws out, or intercepts, a longitudinal one, we must commonly look for the rejected vein on the side of the obtuse angle which the direction of the latter makes with that of the former. When a bed of ore is deranged by a fault, we must observe whether the slip of the strata be upwards or downwards; for in either circumstance, it is only by pursuing the direction of the fault that we can recover the ore; in the former case by mounting, in the latter by descending beyond the dislocation.

When two veins intersect each other, the direction of the *offcast* is a subject of interest, both to the miner and the geologist. In Saxony it is considered as a general fact that the portion thrown out is always upon the side of the obtuse angle, a circumstance which holds also in Cornwall; and the more obtuse the angle, the out-throw is the more considerable. A vein may be thrown out on meeting another vein, in a line which approaches either towards its inclination or its direction. The Cornish miners use two different terms to denote these two modes of rejection; for the first case, they say the vein is *heaved*; for the second, it is *started*.

The great copper lode of Carharack, *d*, fig. 932, in the parish of Gwenap, is one of the most instructive examples of intersection.



The power or thickness of this vein is 8 feet; its direction is nearly due east and west, and it dips towards the north at an inclination of two feet per fathom; its upper part being in the *killas* (a greenish clay-slate); its lower part in the granite. The lode has suffered two intersections; the first produced by meeting the vein *a*, called *Steven's fluckan*, which runs from north-east to south-west, and which throws the lode several fathoms out; the second is produced by

another vein *i*, almost at right angles with the first, and which occasions another out-throw of 20 fathoms to the right side. The fall of the vein occurs therefore in the one case to the right, and in the other to the left; but in both it is towards the side of the obtuse angle. This distribution is very singular; for one part of the vein appears to have mounted while the other has descended. *n. a.* denotes North and South. *d* is the copper lode running east and west. *a, i,* are systems of clay-slate veins called *fluckans*; the line over *a*, represents the down-shift, and *d'* the up-shift.

General observations on the localities of ores, and on the indications of metallic mines.

1. *Tin*, exists principally in primitive rocks, appearing either in interlaced masses, in beds, or as a constituent part of the rock itself, and more rarely in distinct veins. Tin ore is found indeed sometimes in alluvial land, filling up low situations between lofty mountains.

2. *Gold*, occurs either in beds, or in veins, frequently in primitive rocks; though in other formations, and particularly in alluvial earth, it is also found. When this metal exists in the bosom of primitive rocks, it is particularly in schists; it is not found in serpentine, but it is met with in greywacke in Transylvania. The gold of alluvial districts,

called gold of washing or transport, occurs, as well as alluvial tin, among the debris of the more ancient rocks.

3. *Silver*, is found particularly in veins and beds, in primitive and transition formations; though some veins of this metal occur in secondary strata. The rocks richest in it are, gneiss, mica-slate, clay-slate, greywacke, and old alpine limestone. Localities of silver-ore itself are not numerous, at least in Europe, among secondary formations; but it occurs in combination with the ores of copper or of lead.

4. *Copper*, exists in the three mineral epochs; 1. in primitive rocks, principally in the state of pyritous copper, in beds, in masses, or in veins; 2. in transition districts, sometimes in masses, sometimes in veins of copper pyrites; 3. in secondary strata, especially in beds of cupreous schist.

5. *Lead*, occurs also in each of the three mineral epochs; abounding particularly in primitive and transition grounds, where it usually constitutes veins, and occasionally beds of sulphuretted lead (galena). The same ore is found in strata or in veins among secondary rocks, associated now and then with ochreous iron-oxide and calamine (carbonate of zinc); and it is sometimes disseminated in grains through more recent strata.

6. *Iron*, is met with in four different mineral eras, but in different ores. Among primitive rocks, magnetic iron ore and specular iron ore occur chiefly in beds, sometimes of enormous size; the ores of red or brown oxide of iron (hæmatite) are found generally in veins, or occasionally in masses with sparry iron, both in primitive and transition rocks; as also sometimes in secondary strata; but more frequently in the coal-measure strata, as beds of clay-ironstone, of globular iron oxide, and carbonate of iron. In alluvial districts we find ores of clay-ironstone, granular iron-ore, bog-ore, swamp-ore, and meadow-ore. The iron ores which belong to the primitive period have almost always the metallic aspect, with a richness amounting even to 80 per cent. of iron, while the ores in the posterior formations become in general more and more earthy, down to those in alluvial soils, some of which present the appearance of a common stone, and afford not more than 20 per cent. of metal, though its quality is often excellent.

7. *Mercury*, occurs principally among secondary strata, in disseminated masses, along with combustible substances; though the metal is met with occasionally in primitive countries.

8. *Cobalt*, belongs to the three mineral epochs; its most abundant deposits are veins in primitive rocks; small veins containing this metal are found, however, in secondary strata.

9. *Antimony*, occurs in veins or beds among primitive and transition rocks.

10, 11. Bismuth and nickel do not appear to constitute the predominating substance of any mineral deposits; but they often accompany cobalt.

12. *Zinc*, occurs in the three several formations; namely, as sulphuret or blende, particularly in primitive and transition rocks; as calamine, in secondary strata, usually along with oxide of iron, and sometimes with sulphuret of lead.

An acquaintance with the general results collected and classified by geology must be our first guide in the investigation of mines. This enables the observer to judge whether any particular district, should from the nature and arrangement of its rocks, be susceptible of including within its bosom, beds of workable ores; it indicates also, to a certain degree, what substances may probably be met with in a given series of rocks, and what locality these substances will preferably affect. For want of a knowledge of these facts, many persons have gone blindly into researches equally absurd and ruinous.

Formerly indications of mines were taken from very unimportant circumstances; from thermal waters, the heat of which was gratuitously referred to the decomposition of pyrites; from mineral waters, whose course is however often from a far distant source; from vapours incumbent over particular mountain groups; from the snows melting faster in one mineral district than another; from the different species of forest trees, and from the greater or less vigour of vegetation, &c. In general, all such indications are equally fallacious with the divining rod, and the compass made of a lump of pyrites suspended by a thread.

Geognostic observation has substituted more rational characters of metallic deposits, some of which may be called *negative* and others *positive*.

The *negative* indications are derived from that peculiar geological constitution, which from experience or general principles excludes certain metallic matters; for example, granite, and in general every primitive formation, forbids the hope of finding within them combustible fossils (pit-coal), unless it be beds of anthracite; there also it would be vain to seek for sal gem. It is very seldom that granite rocks include silver; or limestones, ores of tin. Volcanic territories never afford any metallic ores worth the working; nor do extensive veins usually run into secondary and alluvial formations. The richer ores of iron do not occur in secondary strata; and the ores of this metal peculiar to these localities, do not exist among primary rocks.

Among *positive* indications, some are proximate and others remote. The proximate are, an efflorescence, so to speak, of the subjacent metallic masses; magnetic attraction for iron ores; bituminous stone, or inflammable gas for pit-coal; the frequent occurrence of fragments of particular ores, &c. The remote indications consist in the geological epoche, and nature of the rocks. From the examples previously adduced, marks of this kind acquire new importance when in a district susceptible of including deposits of workable ores, the *gangues* or vein-stones are met with which usually accompany any particular metal. The general aspect of mountains whose flanks present gentle and continuous slopes, the frequency of sterile veins, the presence of metalliferous sands, the neighbourhood of some known locality of an ore, for instance that of iron-stone in reference to coal, lastly the existence of salt springs and mineral waters, may furnish some indications; but when ferruginous or cupreous waters issue from sands or clays, such characters merit in general little attention, because the waters may flow from a great distance. No greater importance can be attached to metalliferous sands and saline springs.

In speaking of remote indications, we may remark that in several places, and particularly near Clausthal in the Hartz, a certain ore of red oxide of iron occurs above the most abundant deposits of the ores of lead and silver; whence it has been named by the Germans the *iron-hat*. It appears that the iron ore rich in silver, which is worked in America under the name of *pacos*, has some analogy with this substance; but iron ore is in general so plentifully diffused on the surface of the soil, that its presence can be regarded as only a remote indication, relative to other mineral substances, except in the case of clay ironstone with coal.

Of the instruments and operations of subterranean operations. — It is by the aid of geometry in the first place that the miner studies the situation of the mineral deposits, on the surface and in the interior of the ground; determines the several relations of the veins and the rocks; and becomes capable of directing the perforations towards a suitable end.

The instruments are, 1. the magnetic compass, which is employed to measure the direction of a metallic ore, wherever the neighbourhood of iron does not interfere with its functions; 2. the graduated semicircle which serves to measure the inclination, which is also called the clinometer.

3. The chain or cord for measuring the distance of one point from another.

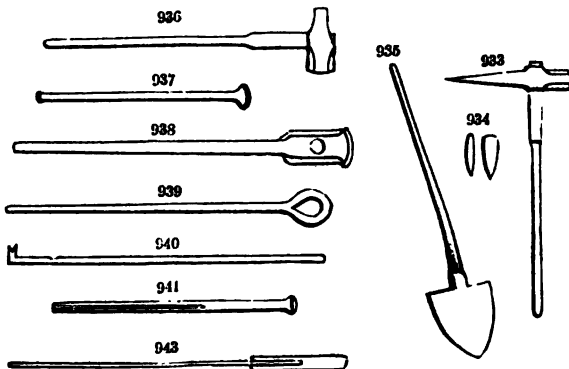
4. When the neighbourhood of iron renders the use of the magnet uncertain, a plate or plane table is employed.

The dials of the compasses generally used in the most celebrated mines, are graduated into hours; most commonly into twice 12 hours. Thus the whole limb is divided into 24 spaces, each of which contains $15^\circ = 1$ hour. Each hour is subdivided into 8 parts.

Means of penetrating into the interior of the earth. — In order to penetrate into the interior of the earth, and to extract from it the objects of his toil, the miner has at his disposal several means, which may be divided into three classes: 1. *manual tools*, 2. *gunpowder*, and 3. *fire*.

The tools used by the miners of Cornwall and Devonshire are the following:

Fig. 933. The *pick*. It is a light tool, and somewhat varied in shape according to cir-



cumstances. One side used as a hammer is called the *poll*, and is employed to drive in the *gads*, or to loosen and detach prominences. The *point* is of steel, carefully tempered, and drawn under the hammer to the proper form. The French call it *pointerolle*.

Fig. 934. The *gad*. It is a wedge of steel, driven into crevices of rocks, or into small openings made with the point of the pick.

Fig. 935. The *miner's shovel*. It has a pointed form, to enable it to penetrate among the coarse and hard fragments of the mine rubbish. Its handle being somewhat bent, a man's power may be conveniently applied without bending his body.

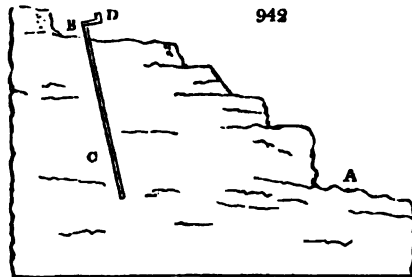
The *blasting or shooting tools* are :—

| | | | | |
|--------------------|---|---|---|------------------|
| A sledge or mallet | - | - | - | <i>fig. 936.</i> |
| Borer | - | - | - | — 937. |
| Claying bar | - | - | - | — 938. |
| Needle or nail | - | - | - | — 939. |
| Scraper | - | - | - | — 940. |
| Tamping bar | - | - | - | — 941. |

Besides these tools the miner requires a powder-horn, rushes to be filled with gunpowder, tin cartridges for occasional use in wet ground, and paper rubbed over with gunpowder or grease, for the *smifts* or fuses.

The *borer*, *fig. 937*, is an iron bar tipped with steel, formed like a thick chisel, and is used by one man holding it straight in the hole with constant rotation on its axis, while another strikes the head of it with the iron sledge or mallet, *fig. 936*. The hole is cleared out from time to time by the scraper, *fig. 940.*, which is a flat iron rod turned up at one end. If the ground be very wet, and the hole gets full of mud, it is cleaned out by a stick bent at the end into a fibrous brush, called a *swab-stick*.

Fig. 942. represents the plan of blasting the rock, and a section of a hole ready for firing. The hole must be rendered as dry as possible, which is effected very simply by filling it partly with tenacious clay, and then driving into it a tapering iron rod, which nearly fills its calibre, called the *claying bar*. This being forced in with great violence, condenses the clay into all the crevices of the rock, and secures the dryness of the hole. Should this plan fail, recourse is had to tin cartridges furnished with a stem or tube (see *fig. 943.*) through which the powder may be inflamed. When the hole is dry, and



the charge of powder introduced, the *nail*, a small taper rod of copper, is inserted so as to reach the bottom of the hole, which is now ready for *tamping*. By this difficult and dangerous process, the gunpowder is confined, and the disruptive effect produced. Different substances are employed for *tamping*, or cramming the hole, the most usual one being any soft species of rock free from siliceous or flinty particles. Small quantities of it only are introduced at a time, and rammed very hard by the *tamping-bar*, which is held steadily by one man, and struck with a sledge by another. The hole being thus filled, the nail is withdrawn by putting a bar through its eye, and striking it upwards. Thus a small perforation or vent is left for the rush which communicates the fire.

Besides the improved tamping-bar faced with hard copper, other contrivances have been resorted to for diminishing the risk of those dreadful accidents that frequently occur in this operation. Dry sand is sometimes used as a tamping material, but there are many rocks for the blasting of which it is ineffective. Tough clay will answer better in several situations.

For conveying the fire, the large and long green rushes which grow in marshy ground are selected. A slit is made in one side of the rush, along which the sharp end of a bit of stick is drawn, so as to extract the pith, when the skin of the rush closes again by its own elasticity. This tube is filled up with gunpowder, dropped into the vent-hole, and made steady with a bit of clay. A paper *smift*, adjusted to burn a proper time, is then fixed to the top of the rush-tube, and kindled, when the men of the mine retire to a safe distance.

In *fig. 942.* the portion of the rock which would be dislodged by the explosion, is that included between *a* and *z*. The charge of powder is represented by the white part which fills the hole up to *c*; from which point to the top, the hole is filled with *tamping*. The *smift* is shewn at *d*.

Fig. 944. is an iron bucket, or as it is called in Cornwall, a *kibble*, in which the ore is raised in the shafts, by machines called *whims*, worked by horses. The best kibbles

are made of sheet-iron, and hold each about three hundred weight of ore: 120 kibbles are supposed to clear a cubic fathom of rock.

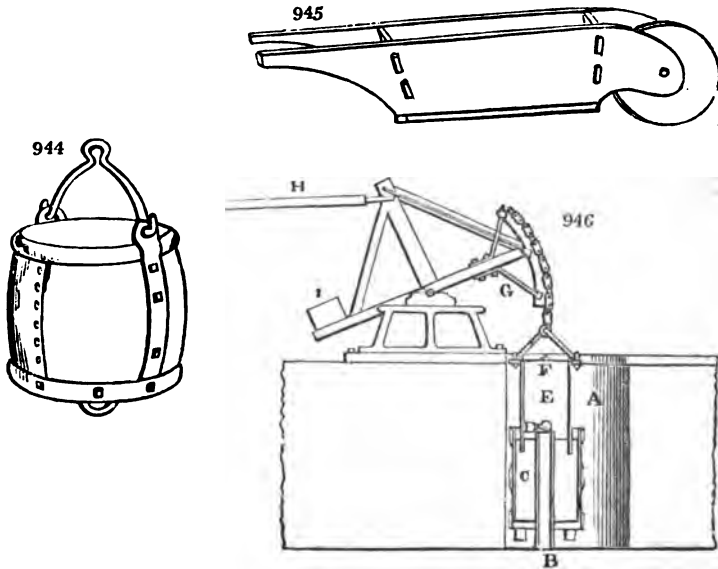


Fig. 945. represents the wheelbarrow used under ground for conveying ore and waste to the foot of the shafts. It is made of light deal, except the wheel, which has a narrow rim of iron.

Fig. 946. represents Mr. Taylor's ingenious ventilator, or machine for renewing fresh air in mines. It is so simple in construction, so complete in its operation, requires so little power to work it, and is so little liable to injury from wear, that nothing further of the kind can be desired in ordinary metallurgic mines. The shaft of the mine is represented at A; at either the top or bottom of which the machine may be placed, as is found most convenient, but the foul air must be discharged into a floor, furnished with a valve-door to prevent its return into the mine. Z is the air-pipe from the mine, passing through the bottom of the fixed vessel or cylinder C, which is formed of timber, and bound with iron hoops. It is filled with water nearly to the top of the pipe X, on which is fixed a valve opening upwards at D. X, the air, or exhausting cylinder of cast-iron, open at bottom, and suspended over the air-pipe, but immersed some way in the water. It is furnished with a wooden top, having an aperture fitted with a valve likewise opening upwards at Y. This exhausting cylinder is moved up and down by the rod C, brought into connexion with any engine by the horizontal rod H; the weight of the cylinder being balanced, if necessary, by the counterpoise I. The action is as follows:—When the cylinder rises, the air from the mine rushes up through the pipe and valve Z; and when it descends, this valve shuts, and prevents the return of the air, which is expelled through the valve Y. With a cylinder two feet in diameter and six feet long, working from two to three strokes per minute, 200 gallons of air may be discharged in the same time.

Gunpowder is the most valuable agent of excavation; possessing a power which has no limit, and which can act every where, even under water. Its introduction, in 1615, caused a great revolution in the mining art.

It is employed in mines in different manners, and in different quantities, according to circumstances. In all cases, however, the process resolves itself into boring a hole, and enclosing a cartridge in it, which is afterwards made to explode. The hole is always cylindrical, and is usually made by means of the borer, *fig. 937.*, a stem of iron, terminated by a blunt-edged chisel. It sometimes ends in a cross, formed by two chisels set transversely. The workman holds the stem in his left hand, and strikes it with an iron mallet held in his right. He is careful to turn the punch a very little round at every stroke. Several punches are employed in succession, to bore one hole; the first shorter, the latter ones longer, and somewhat thinner. The rubbish is withdrawn as it accumulates, at the bottom of the hole, by means of a picker, which is a small spoon or disc of iron fixed at the end of a slender iron rod. When holes of a large size are to be

made, several men must be employed ; one to hold the punch, and one or more to wield the iron mallet. The perforations are seldom less than an inch in diameter, and 18 inches deep ; but they are sometimes 2 inches wide, with a depth of 50 inches.

The gunpowder, when used, is most commonly put up in paper cartridges. Into the side of the cartridge, a small cylindrical spindle or *piercer* is pushed. In this state the cartridge is forced down to the bottom of the hole, which is then stuffed, by means of the tamping bar, *fig. 941.*, with bits of dry clay, or friable stones coarsely pounded.* The piercer is now withdrawn, which leaves in its place, a channel through which fire may be conveyed to the charge. This is executed either by pouring gunpowder into that passage, or by inserting into it, reeds, straw stems, quills, or tubes of paper filled with gunpowder. This is exploded by a long match, which the workmen kindle, and then retire to a place of safety.

As the *piercer* must not only be slender, but stiff, so as to be easily withdrawn when the hole is tamped, iron spindles are usually employed, though they occasionally give rise to sparks, and consequently to dangerous accidents, by their friction against the sides of the hole. Brass piercers have been sometimes tried ; but they twist and break too readily.

Each hole bored in a mine, should be so placed in reference to the schistose structure of the rock, and to its natural fissures, as to attack and blow up the least resisting masses. Sometimes the rock is prepared beforehand for splitting in a certain direction, by means of a narrow channel excavated with the small hammer.

The quantity of gunpowder should be proportional to the depth of the hole, and the resistance of the rock ; and merely sufficient to split it. Any thing additional would serve no other purpose than to throw the fragments about the mine, without increasing the useful effect. Into the holes of about an inch and a quarter diameter, and 18 inches deep, only two ounces of gunpowder are put.

It appears that the effect of the gunpowder may be augmented by leaving an empty space above, in the middle of, or beneath the cartridge. In the mines of Silicia, the consumption of gunpowder has been eventually reduced, without diminishing the product of the blasts, by mixing sawdust with it in certain proportions. The hole has also been filled up with sand in some cases, according to Mr. Jessop's plan, instead of being packed with stones, which has removed the danger of the tamping operation. The experiments made in this way have given results very advantageous in quarry blasts with great charges of gunpowder ; but less favourable in the small charges employed in mines.

Water does not oppose an insurmountable obstacle to the employment of gunpowder ; but when the hole cannot be made dry, a cartridge bag impermeable to water must be had recourse to, provided with a tube also impermeable, in which the *piercer* is placed.

After the explosion of each mining charge, wedges and levers are employed, to drag away and break down what has been shattered.

Wherever the rock is tolerably hard, the use of gunpowder is more economical and more rapid than any tool-work, and is therefore always preferred. A gallery, for example, a yard and a half high, and a yard wide, the piercing of which by the hammer formerly cost from five to ten pounds sterling, the running yard, in Germany, is executed at the present day by gunpowder at from two to three pounds. When, however, a precious mass of ore is to be detached, when the rock is cavernous, which nearly nullifies the action of gunpowder, or when there is reason to apprehend that the shock caused by the explosion may produce an injurious fall of rubbish, hand-tools alone must be employed.

In certain rocks and ores of extreme hardness, the use both of tools and gunpowder becomes very tedious and costly. Examples to this effect are seen, in the mass of quartz mingled with copper pyrites, worked at Rammelsberg, in the Hartz, in the masses of stanniferous granite of Geyer and Altenberg in the Erzgebirge of Saxony, &c. In these circumstances, fortunately very rare, the action of fire is used with advantage to diminish the cohesion of the rocks and the ore. The employment of this agent is not necessarily restricted to these difficult cases. It was formerly applied very often to the working of hard substances ; but the introduction of gunpowder into the mining art, and the increase in the price of wood, occasion fire to be little used as an ordinary means of excavation, except in places where the scantiness of the population has

* Sir Ross Price invented a cap of bronze alloy, to tip the lower end of the iron rod ; a contrivance now generally used in Cornwall. Before the Geological Society of that county introduced this invention into practice, scarcely a month elapsed without some dreadful explosion sending the miner to an untimely grave, or so injuring him by blowing out his eyes, or shattering his limbs, as to render him a miserable object of charity for the rest of his days. Scarcely has any accident happened since the employment of the new tamping-bar. When the whole bar was made of the tin and copper alloy it was expensive, and apt to bend ; but the iron rod tipped with the bronze is both cheap and effectual. An ingenious instrument, called the shifting cartridge, was invented by Mr. Chinalls, and is described in the Transactions of the above society.

left a great extent of forest timber, as happens at Kongsberg in Norway, at Dannemora in Sweden, at Felsobanya in Transylvania, &c.

The action of fire may be applied to the piercing of a gallery, or to the advancement of a horizontal cut, or to the crumbling down of a mass of ore, by the successive upraising of the roof of a gallery already pierced. In any of these cases, the process consists in forming bonfires, the flame of which is made to play upon the parts to be attacked. All the workmen must be removed from the mine during, and even for some time after, the combustion. When the excavations have become sufficiently cool to allow them to enter, they break down with levers and wedges, or even by means of gunpowder, the masses which have been rent and altered by the fire.

To complete our account of the manner in which man may penetrate into the interior of the earth, we must point out the form of the excavations that he should make in it.

In mines, three principal species of excavations may be distinguished; *viz.* *shafts*, *galleries*, and the *cavities* of greater or less magnitude which remain in the room of the old workings.

A *shaft* or *pit* is a prismatic or cylindrical hollow space, the axis of which is either vertical or much inclined to the horizon. The dimension of the pit, which is never less than 32 inches in its narrowest diameter, amounts sometimes to several yards. Its depth may extend to 1000 feet, and more. Whenever a shaft is opened, means must be provided to extract the rubbish which continually tends to accumulate at its bottom, as well as the waters which may percolate down into it; as also to facilitate the descent and ascent of the workmen. For some time a wheel and axle erected over the mouth of the opening, which serve to elevate one or two buckets of proper dimensions, may be sufficient for most of these purposes. But such a machine becomes ere long inadequate. Horse-whims, or powerful steam-engines, must then be had recourse to; and effectual methods of support must be employed to prevent the sides of the shaft from crumbling and falling down.

A *Gallery* is a prismatic space, the straight or winding axis of which does not usually deviate much from the horizontal line. Two principal species are distinguished; the galleries of *elongation*, which follow the direction of a bed or a vein; and the *transverse* galleries, which intersect this direction under an angle not much different from 90°. The most ordinary dimensions of galleries are a yard wide, and two yards high; but many still larger may be seen traversing thick deposits of ore. There are few whose width is less than 24 inches, and height less than 40; such small drifts serve merely as temporary expedients in workings. Some galleries are several leagues in length. We shall describe in the sequel the means which are for the most part necessary to support the roof and the walls. The rubbish is removed by waggons or wheelbarrows of various kinds. See *fig.* 945.

It is impossible to advance the boring of a shaft or gallery beyond a certain rate, because only a limited set of workmen can be made to bear upon it. There are some galleries which have taken more than 30 years to perforate. The only expedient for accelerating the advance of a gallery, is to commence, at several points of the line to be pursued, portions of galleries which may be joined together on their completion.

Whether tools or gunpowder be used in making the excavations, they should be so applied as to render the labour as easy and quick as possible, by disengaging the mass out of the rock at two or three of its faces. The effect of gunpowder, wedges, or picks, is then much more powerful. The greater the excavation, the more important is it to observe this rule. With this intent, the working is disposed in the form of *steps* (*gradins*), placed like those of a stair; each step being removed in successive portions, the whole of which, except the last, are disengaged on three sides, at the instant of their being attacked.

The substances to be mined occur in the bosom of the earth, under the form of alluvial deposits, beds, pipe-veins, or masses, threads or small veins, and rake-veins.

When the existence of a deposit of ore is merely suspected, without positive proof, recourse must be had to labours of research, in order to ascertain the richness, nature, and disposition of a supposed mine. These are divided into three kinds; *open workings*, *subterranean workings*, and *boring operations*.

1. The *working by an open trench*, has for its object to discover the outcropping or baset edges of strata or veins. It consists in opening a fosse of greater or less width, which, after removing the vegetable mould, the alluvial deposits, and the matters disintegrated by the atmosphere, discloses the native rocks, and enables us to distinguish the beds which are interposed, as well as the veins that traverse them. The trench ought always to be opened in a direction perpendicular to the line of the supposed deposit. This mode of investigation costs little, but it seldom gives much insight. It is chiefly employed for verifying the existence of a supposed bed or vein.

The *subterranean workings* afford much more satisfactory knowledge. They are executed by different kinds of perforations; *viz.* by *longitudinal galleries* hollowed out

of the mass of the beds or veins themselves, in following their course; by *transverse galleries*, pushed at right angles to the direction of the veins; by *inclined shafts*, which pursue the slope of the deposits, and are excavated in their mass; or, lastly, by *perpendicular pits*.

If a vein or bed unveils itself on the flank of a mountain, it may be explored, according to the greater or less slope of its inclination, either by a longitudinal gallery opened in its mass, from the outcropping surface, or by a transverse gallery falling upon it in a certain point, from which either an oblong gallery or a sloping shaft may be opened.

If our object be to reconnoitre a highly inclined stratum, or a vein in a level country, we shall obtain it with sufficient precision, by means of shafts, 8 or 10 yards deep, dug at 30 yards distance from one another; excavated in the mass of ore, in the direction of its deposit. If the bed is not very much inclined, only 45°, for example, vertical shafts must be opened in the direction of its roof, or of the superjacent rocky stratum, and galleries must be driven from the points in which they meet the ore, in the line of its direction.

When the rocks which cover valuable minerals are not of very great hardness, as happens generally with the coal formation, with pyritous and aluminous slates, sal gem, and some other minerals of the secondary strata, the *borer* is employed with advantage to ascertain their nature. This mode of investigation is economical, and gives, in such cases, a tolerably exact insight into the riches of the interior. The method of using the borer, has been described under **ARTESIAN WELLS**.

OF MINING IN PARTICULAR.

The mode of working mines is two-fold; by *open excavations*, and *subterranean*.

Workings in the open air present few difficulties, and occasion little expense, unless when pushed to a great depth. They are always preferred for working deposits little distant from the surface; where, in fact, other methods cannot be resorted to, if the substance to be raised be covered with incoherent matters. The only rules to be observed are, to arrange the workings in terraces, so as to facilitate the cutting down of the earth; to transport the ores and the rubbish to their destination at the least possible expense; and to guard against the crumbling down of the sides. With the latter view, they ought to have a suitable slope, or to be propped by timbers whenever they are not quite solid.

Open workings are employed for valuable clays, sands, as also for the alluvial soils of diamonds, gold, and oxide of tin, bog iron ores, &c., limestones, gypsums, building stones, roofing slates, masses of rock salt in some situations, and certain deposits of ores, particularly the specular iron of the island of Elba; the masses of stanniferous granite of *Gayer*, *Altenberg*, and *Seyffen*, in the *Ertzgeberge*, a chain of mountains between Saxony and Bohemia; the thick veins or masses of black oxide of iron of Nordmarch, Dannemora, &c., in Sweden; the mass of cupreous pyrites of *Raræas*, near Drontheim, in Norway; several mines of iron, copper, and gold in the Ural mountains, &c.

Subterranean workings may be conveniently divided into five classes, viz. :—

1. Veins, or beds, much inclined to the horizon, having a thickness of at least two yards.
2. Beds of slight inclination, or nearly horizontal, the power or thickness of which does not exceed two yards.
3. Beds of great thickness, but slightly inclined.
4. Veins, or beds highly inclined, of great thickness.
5. Masses of considerable magnitude in all their dimensions.

Subterranean mining requires two very distinct classes of workings; the *preparatory*, and those for *extraction*.

The *preparatory* consist in galleries, or in pits and galleries destined to conduct the miner to the point most proper for attacking the deposit of ore, for tracing it all round this point, for preparing chambers of excavation, and for concerting measures with a view to the circulation of air, the discharge of waters, and the transport of the extracted minerals.

If the vein or bed in question be placed in a mountain, and if its direction forms a very obtuse angle with the line of the slope, the miner begins by opening in its side, at the lowest possible level, a gallery of elongation, which serves at once to give issue to the waters, to explore the deposit through a considerable extent, and then to follow it in another direction; but to commence the real mining operations, he pierces either shafts or galleries, according to the slope of the deposit, across the first gallery.

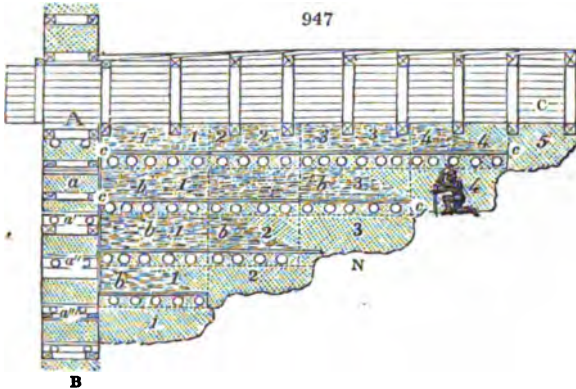
For a stratum little inclined to the horizon, placed beneath a plain, the first thing is to pierce two vertical shafts, which are usually made to arrive at two points in the same line of slope, and a gallery is driven to unite them. It is, in the first place, for the sake of circulation of air that these two pits are sunk; one of them, which is also destined for the drainage of the waters, should reach the lowest point of the intended workings.

If a vein is intersected by transverse ones, the shafts are placed so as to follow, or, at least, to cut through the intersections. When the mineral ores lie in nearly vertical masses, it is right to avoid, as far as possible, sinking pits into their interior. These should rather be perforated at one side of their floor, even at some considerable distance, to avoid all risk of crumbling the ores into a heap of rubbish, and overwhelming the workmen.

With a vein of less than two yards thick, as soon as the preparatory labours have brought the miners to the point of the vein from which the ulterior workings are to ramify, whenever a circulation of air has been secured, and an outlet to the water and the matters mined, the first object is to divide the mass of ore into large parallelepipeds, by means of oblong galleries, pierced 20 or 25 yards below one another, with pits of communication opened up, 30, 40, or 50 yards asunder, which follow the slope of the vein. These galleries and shafts are usually of the same breadth as the vein, unless when it is very narrow, in which case it is requisite to cut out a portion of the roof or the floor. Such workings serve at once the purposes of mining, by affording a portion of ore, and the complete investigation of the nature and riches of the vein, a certain extent of which is thus prepared before removing the cubical masses. It is proper to advance first of all, in this manner, to the greatest distance from the central point which can be mined with economy, and afterwards to remove the parallelepiped blocks, in working back to that point.

This latter operation may be carried on in two different ways; of which one consists in attacking the ore from above; and another from below. In either case, the excavations are disposed in steps similar to a stair upon their upper or under side. The first is styled a *working* in direct or descending steps; and the second a *working* in reverse, or ascending steps.

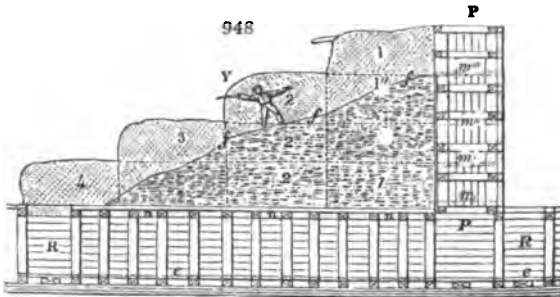
1. Suppose, for example, that the post *x*, *fig.* 947., included between the horizontal



gallery *ac* and the shaft *ab*, is to be excavated by direct steps, a workman stationed upon a scaffold at the point *a*, which forms the angle between the shaft and the elongated drift, attacks the rock in front of him and beneath his feet. Whenever he has cut out a parallelepiped (a rectangular mass), of from four to six yards broad, and two yards high, a second miner is set to work upon a scaffold at *a'*, two yards beneath the first, who, in like manner, excavates the rock under his feet and before him. As soon as the second miner has removed a post of four or six yards in width, by two in height, a third begins upon a scaffold at *a''* to work out a third step. Thus, as many workmen are employed as there are steps to be made between the two oblong horizontal galleries which extend above and below the mass to be excavated; and since they all proceed simultaneously, they continue working in similar positions, in floors, over each other, as upon a stair with very long wide steps. As they advance, the miners construct before them wooden floors *c c c c*, for the purpose of supporting the rubbish which each workman extracts from his own step. This floor, which should be very solid, serves also for wheeling out his barrow filled with ore. The round billets which support the planks sustain the roof or the wall of the mineral vein or bed under operation. If the rubbish be very considerable, as is commonly the case, the floor planks are lost. However strongly they may be made, as they cannot be repaired, they sooner or later give way under the enormous pressure of the rubbish; and as all the weight is borne by the roof of the oblong gallery underneath, this must be sufficiently timbered. By this ingenious plan, a great many miners may go to work together upon a vein without mutual interference; as the portions which they detach have always two faces at least free, they are consequently more easily separable, either

with gunpowder or with the pick. Should the vein be more than a yard thick, or if its substance be very refractory, two miners are set upon each step. *b b b b* indicate the quadrangular masses that are cut out successively downwards; and 1 1, 2 2, 3 3, forwards; the lines of small circles are the sections of the ends of the billets which support the floors.

2. To attack a mass *r*, *fig. 948.*, a scaffold *m*, is erected in one of its terminal pits *r r*,



at the level of the ceiling of the gallery *x x'*, where it terminates below. A miner placed on this scaffold, cuts off at the angle of this mass a parallelepiped 1, from one to two yards high, by six or eight long. When he has advanced thus far, there is placed in the same pit, upon another scaffold *m'*, a second miner, who attacks the vein above the roof of the first cutting, and hews down, above the parallelepiped 1, a parallelepiped of the same dimensions 1', while the first is taking out another 2, in advance of 1. When the second miner has gone forward 6 or 8 yards, a third is placed also in the same pit. He commences the third step, while the first two miners are pushing forwards theirs, and so in succession.

In this mode of working, as well as in the preceding, it is requisite to support the rubbish and the walls of the vein. For the first object, a single floor *x x x*, may be sufficient, constructed above the lower gallery, substantial enough to bear all the rubbish, as well as the miners. In certain cases, an arched roof may be substituted; and in others, several floors are laid at different heights. The sides of the vein are supported by means of pieces of wood fixed between them perpendicularly to their planes. Sometimes, in the middle of the rubbish, small pits are left at regular distances apart, through which the workmen throw the ore coarsely picked, down into the lower gallery. The rubbish occasionally forms a slope *f f f*, so high that miners placed upon it can work conveniently. When the rich portions are so abundant as to leave too little rubbish to make such a sloping platform, the miners plant themselves upon movable floors, which they carry forward along with the excavations.

These two modes of working in the *step-form*, have peculiar advantages and disadvantages; and each is preferred to the other according to circumstances.

In the *descending workings* or in *direct steps*, *fig. 947.*, the miner is placed on the very mass or substance of the vein; he works commodiously before him; he is not exposed to the splinters which may fly off from the roof; but by this plan he is obliged to employ a great deal of timber to sustain the rubbish; and the wood is fixed for ever.

In the *ascending workings*, or in *reversed steps*, *fig. 948.*, the miner is compelled to work in the re-entering angle formed between the roof and the front wall of his excavation, a posture sometimes oppressive; but the weight of the ore conspires with his efforts to make it fall. He employs less timber than in the *workings with direct steps*. The *sorting* of the ore is more difficult than in the *descending working*, because the rich ore is sometimes confounded with the heap of rubbish on which it falls.

When seams of diluvium or gravel-mud, occur on one of the sides of the vein, or on both, they render the quarrying of the ore more easy, by affording the means of uncovering the mass to be cut down, upon an additional face.

Should the vein be very narrow, it is necessary to remove a portion of the sterile rock which encloses it, in order to give the work a sufficient width to enable the miner to advance. If, in this case, the vein be quite distinct from the rock, the labour may be facilitated, as well as the separation of the ore, by disengaging the vein, on one of its faces through a certain extent, the rock being attacked separately. This operation is called *stripping the vein*. When it is thus uncovered, a shot of gunpowder is sufficient to detach a great mass of it, unmixed with sterile stones.

By the methods now described, only those parallelepipeds are cut out, either in whole or in part, which present indications of richness adequate to yield a prospect of benefit. In other cases, it is enough to follow out the threads of ore which occur, by workings made in their direction.

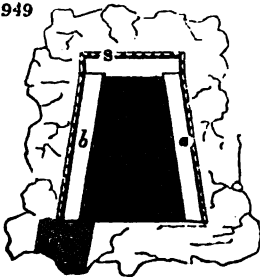
The miner, in searching within the crust of the earth for the riches which it conceals, is exposed to many dangers. The rocks amidst which he digs are seldom or never entire, but are almost always traversed by clefts in various directions, so that impending fragments threaten to fall and crush him at every instant. He is even obliged at times to cut through rotten friable rocks or alluvial loams. Fresh atmospheric air follows him with difficulty in the narrow channels which he lays open before him; and the waters which circulate in the subterranean seams and fissures filter incessantly into his excavation, and tend to fill it. Let us now take a view of the means he employs to escape from these three classes of dangers.

1. *Of the timbering of excavations.* — The excavations of mines, are divisible into three principal species; *shafts, galleries, and chambers.* When the width of these excavations is inconsiderable, as is commonly the case with shafts and galleries, their sides can sometimes stand upright of themselves; but more frequently they require to be propped or stayed by billets of wood, or by walls built with bricks or stones; or even by stuffing the space with rubbish. These three kinds of *support* are called *timbering, walling, and filling up.*

Timbering is most used. It varies in form for the three species of excavations, according to the solidity of the walls which it is destined to sustain.

In a gallery, for example, it may be sufficient to support merely the roof, by means of joists placed across, bearing at their two ends in the rock; or the roof and the two walls by means of an upper joist *s*, *fig. 949.*, which is then called a *cap* or *cornice beam*,

949



resting on two lateral upright posts or *stanchions*, *a, b*, to which a slight inclination towards each other is given, so that they approach a little at the top, and rest entirely upon the floor. At times, only one of the walls and the roof need support. This case is of frequent occurrence in pipe veins. Pillars are then set up only on one side, and on the other the joists rest in holes of the rock. It may happen that the floor of the gallery shall not be sufficiently firm to afford a sure foundation to the standards; and it may be necessary to make them rest on a horizontal piece called the *sole*. This is timbering with *complete frames*. The upright posts are usually set directly on the sole; but the extremities of the *cap* or ceiling, and the upper ends of the *standards*, are mortised in such a manner that these cannot come nearer, whereby the cap shall possess its whole force of resistance. In

friable and shivery rocks there is put behind these beams, both upon the ceiling and the sides, *facing boards*, which are planks placed horizontally, or spars of cleft wood, set so close together as to leave no interval. They are called *fascines* in French. In ordinary ground, the miner puts up these *planks* in proportion as he goes forwards; but in a loose soil, such as sand or gravel, he must mount them a little in advance. He then drives into the mass behind the wooden frame-work, thick but sharp-pointed planks or stakes, and which, in fact, form the sides of the cavity, which he proceeds to excavate. Their one extremity is thus supported by the earth in which it is thrust, and their other end by the last framing. Whenever the miner gets sufficiently on, he sustains the walls by a new frame. The size of the timber, as well as the distance between the frames or *stanchions*, depends on the degree of pressure to be resisted.

When a gallery is to serve at once for several distinct purposes, a greater height is given to it; and a flooring is laid on it at a certain level. If, for example, a gallery is to be employed, both for the transport of the ores and the discharge of the waters, a floor *s e*, *fig. 948.*, is constructed above the bottom, over which the carriages are wheeled, and under which the waters are discharged.

The timbering of shafts varies in form, as well as that of galleries, according to the nature and the locality of the ground which they traverse, and the purposes which they are meant to serve. The shafts intended to be stayed with timber are usually square or rectangular, because this form, in itself more convenient for the miner, renders the execution of the timbering more easy. The wood-work consists generally of rectangular frames, the spars of which are about eight inches in diameter, and placed at a distance asunder of from a yard to a yard and a half. The spars are never placed in contact, except when the pressure of the earth and the waters is very great. The pieces composing the frames are commonly united by a half-check, and the longer of the two pieces extends often beyond the angles, to be rested in the rock. Whether the shaft is vertical or inclined, the frame-work is always placed so that its plane may be perpendicular to the axis of the pit. It happens sometimes in inclined shafts that there are only two sides, or even a single one, which needs to be propped. These are stayed by means of cross beams, which rest at their two ends in the rock. When the frames

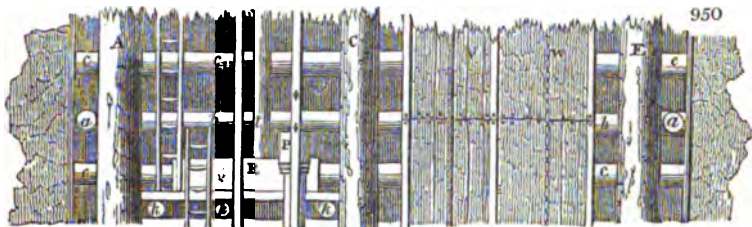
do not touch one another, strong planks or stakes are fastened behind them to sustain the ground. To these planks the frames are firmly connected, so that they cannot slide. In this case the whole timbering will be supported, when the lower frame is solidly fixed, or when the pieces from above pass by its angles to be abuted upon the ground.

In the large rectangular shafts, which serve at once for extracting the ores, for the discharge of the waters, and the descent of the workmen, the spaces destined for these several purposes are in general separated by partitions, which also serve to increase the strength of the timberings, by acting as buttresses to the planks in the long sides of the frame-work. Occasionally a partition separates the ascending from the descending basket, to prevent their jostling. — Lastly, particular passages are left for ventilation.

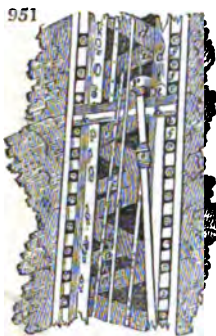
As it is desirable that the wood shall retain its whole force, only those pieces are squared which absolutely require it. The spars of the frames in shafts and galleries are deprived merely of their bark, which by holding moisture, would accelerate the decomposition of the wood. The albuminum of oak is also removed.

Resinous woods, like the pine, last much shorter than the oak, the beech, and the cherry-tree; though the larch is used with advantage. The oak has been known to last upwards of 40 years; while the resinous woods decay frequently in 10. The fresher the air in mines, the more durable is the timbering.

The marginal *figs.* 950, 951. represent two vertical sections of a shaft, the one at right



angles to the other, with the view of showing the mode of sustaining the walls of the excavation by timbering.



It is copied from an actual mine in the Hartz. There we may observe the spaces allotted to the descent of the miners by ladders, to the drainage of the waters by pumps *r*, and rods *z*, and to the extraction of the mineral substances by the baskets *B*. *a, b, c, f, h, k*, various cross timbers; *A, C, E*, upright do.; *x*, pump cistern; *v, w*, corve-ways. The shafts here shown, are excavated in the line of the vein itself, — the rock enclosing it being seen in the second figure.

In a great many mines it is found advantageous to support the excavations by brick or stone buildings, constructed either with or without mortar. These constructions are often more costly than wooden ones, but they last much longer, and need fewer repairs. They are employed instead of timberings, to support the walls and roof of galleries, to line the sides of shafts, and to bear up the roofs of excavations.

Sometimes the two sides of a gallery are lined with vertical walls, and its roof is supported by an ogee vault, or an arch. If the sides of the mine are solid, a simple arch is sufficient to sustain the roof and at other times the whole surface of a gallery is formed of a single elliptic vault, the great axis of which is vertical; and the bottom is surmounted by a wooden plank, under which the waters run off; see *fig.* 952.

Walled shafts also are sometimes constructed in a circular or elliptic form, which is better adapted to resist the pressure of the earth and waters. Rectangular shafts of all dimensions, however, are frequently walled.

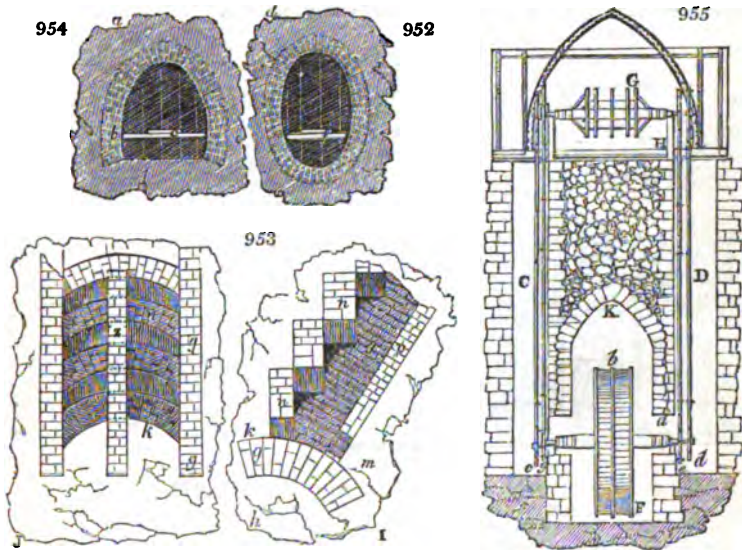
The sides of an excavation may also be supported by filling it completely with rubbish. Wherever the sides need to be supported for some time without the necessity of passing along them, it is often more economical to stuff them up with rubbish, than to keep up their supports. In the territory of Liege, for example, there have been shafts thus filled up for several centuries; and which are found to be quite entire when they are emptied. The rubbish is also useful for forming roads among steep strata, for closing air-holes, and forming canals of ventilation.

Figs. 952. 953. 954. represent the principal kinds of mason-work employed in the galleries and shafts of mines. *Fig.* 955. exhibits the walling in of the cage of an over-shot water-wheel, as mounted within a mine. Before beginning to build, an exca-

vation large enough must be made in the gallery to leave a space three feet and a half high for the workmen to stand in, after the brick-work is completed. Between the two opposite sides, cross beams of wood must be fixed at certain distances, as chords of the vault, over which the rock must be hollowed out to receive the arch-stones, and the centring must then be placed, covered with deals to receive the *voussoirs*, beginning at the flanks and ending with the key-stone. When the vault is finished through a certain extent, the interval between the arch and the rock must be rammed full of rubbish, leaving passages if necessary through it and the arch, for currents of water.

In walling galleries, attention must be paid to the direction of the pressure, and to build vertically or with a slope accordingly. Should the pressure be equal in all directions, a closed vault, like *fig. 952.*, should be formed. For walls not far from the vertical, salient or buttressed arches are employed, as shown in *fig. 953.*, called in German *überspringende bogen*; for other cases, twin-arches are preferred, with an upright wall between.

Fig. 954. is a transverse section of a walled drain-gallery, from the grand gallery of the Hartz; see also *fig. 955.* *a* is the rock which needs to be supported only at the sides



and top; *b*, the masonwork, a curve formed of the three circular arcs upon one level; *c*, the floor for the watercourse. *Fig. 952.* is a cross section of a walled gallery, as at Schneeberg, Rothenburg, Idria, &c.; *d*, is the rock, which is not solid either at the flanks, roof, or floor; *e*, the elliptic masonwork; *f*, the wooden floor for the waggons, which is sometimes, however, arched in brick to allow of a watercourse beneath it.

Fig. 953. shows two vertical projections of a portion of a walled shaft with buttresses, as built at the mine *Vater Abraham*, near Marienberg. *J* is a section in the direction of the vein *g h*, to show the roof of the shaft. *i*, a section exhibiting the slope of the vein *g h*, into which the shaft is sunk; *m* is the wall of the vein; *k* is the roof of the same vein; *n*, buttresses resting upon the flanks of the shaft; *g*, great arcs on which the buttresses bear; *y*, vertical masonwork; *x*, a wall which divides the shaft into two compartments, of which the larger *p* is that for extracting the ore, and the smaller for the draining and descent of the miners.

Fig. 955. *c d* is the shaft in which the vertical crank-rods *c g*, *e d*, move up and down. *r*, is a double hydraulic wheel, which can be stopped at pleasure by a brake mounted upon the machine of extraction. *a*, is the drum of the gig or whim for raising the *corres* or tubs (*tonnes*); *n*, is the drum of the gig or whim for raising the *corres* or tubs (*tonnes*); *n*, is the level of the ground, with the carpentry which supports the whim and its roof. *h*, is the key-stone of the *ogee* arch which covers the water-wheel; *a*, is the opening or window, traversed by the extremity of the driving shaft, upon each side of the water-wheel, through which a workman may enter to adjust or repair it; *b*, line of conduits for the streams of water which fall upon the hydraulic

wheel; *e, g*, double crank with rods, whose motion is taken off the left side of the wheel; *s, d*, the same upon the right side. The distance from *u* to *r* is about 22 yards.

Figs. 956. 957. present two vertical sections of the shaft of a mine walled, like the roof of a cavern, communicating with the galleries of the roof and the wall of the vein, and well arranged for both the extraction of the ore, and the descent of the miners. The vertical partition of the shaft for separating the passage for the corves or tubs from the ladders is omitted in the figure, for the sake of clearness.

In *fig. 956.*, *A, B* are the side walls supported upon the buttresses *c* and *D*; in *fig. 957.*, *X* is the masonry of the wall, borne upon the arch *r* at the entrance to a gallery; the continuation being at *a*, which is sustained by a similar arch built lower.

L, is the vault arch of the roof, supported upon another vault *M*, which presents a double curvature, at the entrance of a gallery; at *N* is the continuation of the arch or vault *L*, which underneath is supported in like manner at the entrance of a lower gallery.

a, h, c, d, *fig. 956.*, are small upright guide-bars or rods for one of the corves, or kibbles.

e, f, g, h, are similar guide-bars for the other corf.

i, i, are cross-bars of wood, which support the stays of the ladders of descent.

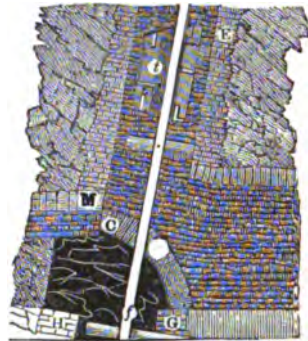
k, k, are also cross-bars by which the guide-rods are secured.

t, a corf, or extraction kibble, furnished with friction rollers; the other corf is supposed to be drawn up to a higher level, in the other vertical passage.

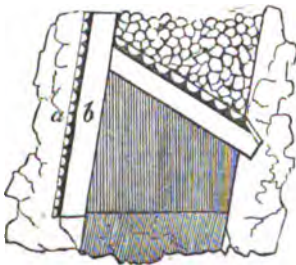
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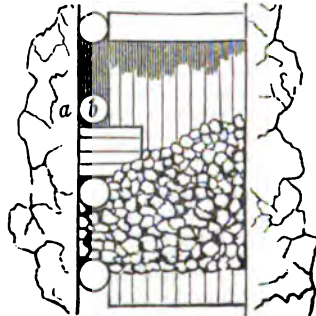
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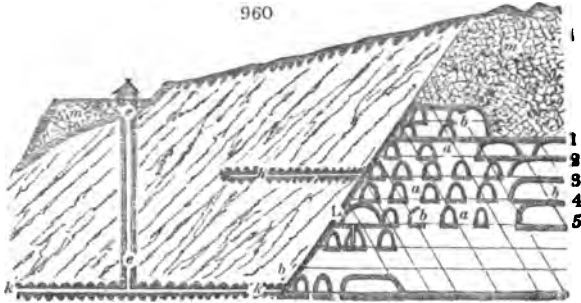
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Figs. 958. 959. represent in a vertical section the mode of timbering the galleries of the silver and lead mines at Andreasberg in the Hartz. *Fig. 958.* shows the plan viewed from above. Upon the roof of the timbering, the workman throws the waste rubbish, and in the empty space below, which is shaded black, he transports in his waggons or wheelbarrows the ores towards the mouth of the mine. *Fig. 959.* is the cross section of the gallery. In the two figures, *a* represents the rock, and *b* the timbering; round which there is a garniture of small spars or lathes for the purpose of drainage and ventilation, with the view of promoting the durability of the wood-work.

The working of minerals by the *mass* is well exemplified a few leagues to the north of Siegen, near the village of Müsen, in a mine of iron and other metals, called *Stahlberg*, which forms the main wealth of the country. The plan of working is termed the *excavation of a direct or transverse mass*. It shows in its upper part the danger of bad mining, and in its inferior portion, the regular workings, by whose means art has eventually prevented the destruction of a precious mineral deposit.

Fig. 960. is a vertical section of the bed of ore, which is a *direct mass* of spathose



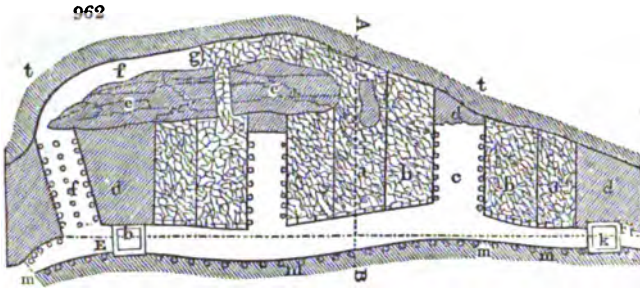
iron, contained in transition rock (greywacke). *a, a, a*, are pillars of the sparry ore, reserved to support the successive stages or floors, which are numbered 1. 2. 3. &c.; *b, b, b*, are excavations worked in the ore; which exhibit at the present day several floors of arches, of greater or less magnitude, according to the localities. It may be remarked, that where the metallic deposit forms one entire mass, rich in spathose iron ore of good quality, there is generally given to the vaults a height of three fathoms; leaving a thickness over the roof of two fathoms, on account of the numerous fissures which pervade the mass. But where this mass is divided into three principal branches, the roof of the vaults has only a fathom and a half of thickness, while the excavation is three fathoms and a half high. In the actual state of the workings, it may be estimated that from all this direct mass, there is obtained no more out of every floor than one-third of the mineral. Two-thirds remain as labours of reserve, which may be resumed at some future day, in consequence of the regularity and the continuation of the subterranean workings. *s* is a shaft for extraction, communicating below with the gallery of efflux *k*; *k* is an upper gallery of drainage, which runs in different directions (one only being visible in this section) over a length of 400 fathoms. The lower gallery *k* runs 646 fathoms in a straight line. The mine of Stahlberg has furnished annually on an average since 1760 about 25,000 cubic feet (French) of an excellent spathose ore of iron. *m m*, represents the mass of sparry iron.

Figs. 961, 962, 963. represent the cross system of mining, which consists in forming galleries through a mineral deposit, from its wall or floor towards its roof, and not, as usual, in the direction of its length. This mode was contrived towards the middle of the 18th century, for working the very thick veins of the Schemnitz mine in Hungary, and it is now employed with advantage in many places, particularly at Idria in Carniola. In the two sections Figs. 961., 963., as well as in the ground plan fig. 962., the wall is denoted by *m m*, and the roof by *t t*. A first gallery of prolongation *x r*, fig. 963., being formed to the

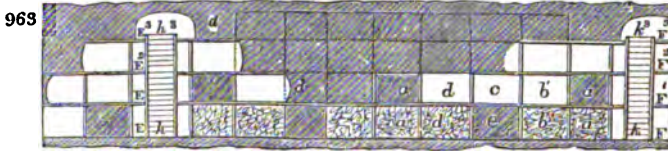
wall, transverse cuts, *a a*, are next established at right angles to this gallery, so that between every two there may be room enough to place three others, *b, c, b*, fig. 962. From each of the cuts *a*, ore is procured by advancing with the help of timbering, till the roof *t* be reached. When this is done, these first cuts *a*, are filled up with rubbish, laid upon pieces of timber with which the ground is covered, so that if eventually, it should be wished to mine underneath, no downfall of detritus is to be feared. These heaps of rubbish rise only to within a few inches of the top of the cuts *a*, in order that the working of the upper story may be easier, the bed of ore being there already laid open upon its lower face.

In proportion as the cuts *a*, of the first story *x r*, are thus filled up, the greater part of the timbering is withdrawn, and made use of elsewhere. The intermediate cuts *b, c, b*, are next mined in like manner, either beginning with the cuts *c*, or the cuts *b*, according to the localities. From fig. 962. it appears that the working may be so arranged, that in case of necessity, there may be always between two cuts in activity the

distance of three cuts, either not made, or filled up with rubbish. Hence, all the portion of the bed of ore may be removed, which corresponds to a first story πr , *fig. 963.*, and this portion is replaced by rubbish.



The exploration of the upper stories $\pi' r'$, $\pi^2 r^2$, $\pi^3 r^3$, is now prepared in a similar manner; with which view shafts $k k^2$, $k k^3$, are formed from below upwards in the wall m of the deposit, and from these shafts oblong galleries proceed, established successively on a level with the stories thus raised over one another. See *fig. 963.* The following objects may be specified in the figures: —



- $a a$, the first cuts filled up with rubbish, upon the first story πr , *fig. 962.*
- $b b$, other cuts subsequently filled up, upon the same story.
- c , the cut actually working.
- d , the front of the cut, or place of actual excavation of the mineral deposit.
- e , masses of the barren rock, reserved in the cutting, as pillars of safety.
- f , galleries, by means of which the workmen may turn round the mass e , in order to form, in the roof t , an excavation in the direction of the deposit.
- g , rubbish behind the mass e .
- $k k$, two shafts leading from the first story πr , to the upper stories of the workings, as already stated.

m , the wall, and t the roof of the mineral bed.

In the second story $\pi' r'$, the gallery of prolongation r' , *figs. 961. and 963.*, is not entirely perforated; but it is further advanced than that of the third story, which, in its turn, is more than the gallery of the fourth.

From this arrangement there is produced upon *fig. 963.* the general aspect of a working by reversed steps.

Whenever the workings of the cuts c in the first story are finished, those of the second, $a' a'$, may be begun in the second; and thus by mounting from story to story, the whole deposit of ore may be taken out and replaced with rubbish. One great advantage of this method is, that nothing is lost; but it is not the only one. The facilities offered by the system of *cross workings* for disposing of the rubbish, most frequently a nuisance to the miner, and expensive to get rid of, the solidity which it procures by the banking up, the consequent economy of timbering, and saving of expense in the excavation of the rock, reckoning from the second story, are so many important circumstances which recommend this mode of mining. Sometimes, indeed, rubbish may be wanted to fill up, but this may always be procured by a few accessory perforations; it being easy to establish in the vicinity of the workings a vast excavation in the form of a vault, or kind of subterraneous quarry, which may be allowed to fall in with proper precautions, and where rubbish will thus accumulate in a short time, at little cost.

Fig. 964 represents a section of the celebrated lead mines of Bleyberg in Carinthia, not far from Villach.

b, c , is the ridge of the mountains of compact limestone, in whose bosom the workings are carried on.

e , is the metalliferous valley, running from east to west, between the two parallel

valleys of the Gail and the Drave, but at a level considerably above the waters of those rivers.

f g, is the direction of a great many vertical beds of metalliferous limestone.

On considering the direction and dip of the marly schist, and metalliferous limestone, in the space *w, w*, to the west of the line *l, s*, it would appear that a great portion of this system of mountains has suffered a slip between *l, s*, and a parallel one towards the east; whereby, probably, that vertical position of the strata has been produced, which exists through a considerable extent. The metalliferous limestone is covered to a certain thickness with a marly schist, and other more recent rocks. It is in this schist that the fine marble known under the name of the *lumachello* of *Bleyberg* is quarried.

The galena occurs in the bosom of this rock in flattened masses, or blocks of a considerable volume, which are not separated from the rest of the calcareous beds by any seam. It is accompanied by zinc ore (*calamine*), especially in the upper parts of the mountain.

Several of the workable masses are indicated by *r, r'*; each presents itself as a solid analogous to a very elongated ellipse, whose axis dips, not according to the inclination of the surrounding rock, but to an oblique or intermediate line between this inclination, and the direction of the beds of limestone; as shown by *r w, r' u*. Every thing indicates the contemporaneous formation of the limestone, and the lying beds of the lead ore.

The accidents or faults called *kluft* (*rent*) at *Bleyberg* are visible on the surface of the ground. Experienced miners have remarked that the rich masses occur more frequently in the direction of these accidents than elsewhere.

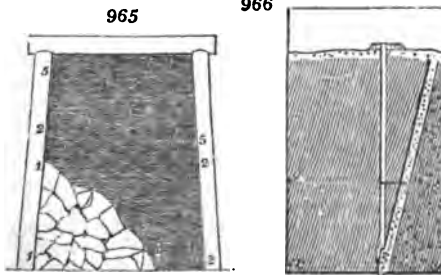
It is in general by galleries cut horizontally in the body of the mountain, and at different levels, *s, g, s'*, that the miner advances towards the masses of ore *r, r'*. Many of these galleries are 500 fathoms long before they reach a workable mass. The several galleries are placed in communication by a few shafts, such as *t*, but few of these are sunk deeper than the level of the valley *e*.

The total length of the mines of *Bleyberg* is about 10,000 yards, parallel to the valley *e*; in which space there are 500 concessions granted by the government to various individuals or joint stock societies, either by themselves or associated with the government.

The metalliferous valley contains 5000 inhabitants, all deriving subsistence from the mines; 300 of whom are occupied in the government works.

Each concession has a number and a name; as *Antoni, Christoph, Matthæus, Oswaldi, 2, 8, 36, &c.*

Fig. 965. is a section in the quicksilver mine of *Idria*. 1. is the gray-limestone; 2. is a blackish slate; 5. is a grayish slate. Immediately above these transition rocks lies the bed containing the ores called *corallenerz*, which consist of an intimate mixture of sulphuret of mercury and argillaceous limestone; in which four men can cut out, in a month, $2\frac{1}{2}$ toises cube of rock.



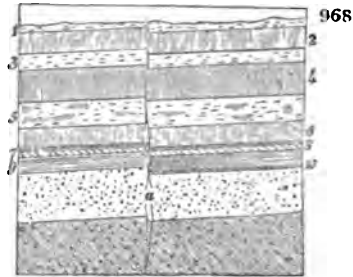
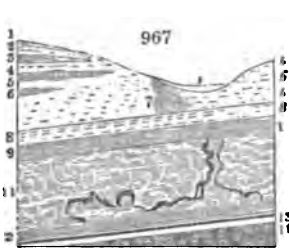
vein at its side is sand; next is *rauchwacke*; and lastly, the main body of fetid limestone, or *stinkstein*.

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Fig. 966. represents a section of part of the copper mine of *Mansfeldt*; containing the cellular limestone, called *rauchwacke*, always with the compact marl-limestone called *zechstein*; the cupreous schist, or *kupferschiefer*; the wall of grayish-white sandstone, called the *weisse liegende*; and the wall of red sandstone, or the *rothelie gende*. The thin dotted stratum at top is vegetable mould; the large dotted portion to the right of the figure is oolite; the

Fig. 967. represents one of the Mansfeldt copper schist mines in the district called Burgörner, or Preusschoheit.

1. Vegetable mould, with siliceous gravel.
2. Ferruginous clay or loam.
3. Sand, with fragments of quartz.
4. Red clay, a bed of variable thickness as well as the lower strata, according as the cupreous schist is nearer or farther from the surface.
5. Oolite (*roogenstein*).
6. Newer variegated sandstone, (*bunter sandstein*).
7. Newer gypsum; below which, there is
8. A bluish marly clay.
9. Stinkstone, or lucullite.
10. Friable grayish marl.
11. Older gypsum, a rock totally wanting in the other districts of the mines of Rothenberg; but abounding in Saxon Mansfeldt, where it includes vast caverns known among the miners by the name of *schlotten*, as indicated in the figure.
12. The calcareous rock called *zechstein*. The lower part of this stratum shows symptoms of the cupriferous schist that lies underneath. It presents three thin bands, differently modified, which the miner distinguishes as he descends by the names of the sterile or rotten (*fäule*) rock; the roof (*dachklotz*); and the main rock (*oberberg*.)



13. Is a bed of cupriferous schist (*kupferschiefer*), also called the *bitumino-marly* schist, in which may be noted, in going down, but not marked in the figure: —

- a, the *lochberg*, a seam 4 inches thick.
- b, the *kammshale*, $\frac{1}{2}$ of an inch thick.
- c, the *kopfschale*, one inch thick.

These seams are not worth smelting; the following, however, are: —

- d, the *schiefer kopf*, the main copper-schist, 2 inches thick.
- e, a layer called *lochen*, one inch thick.

14. The wall of sandstone, resting upon a porphyry.

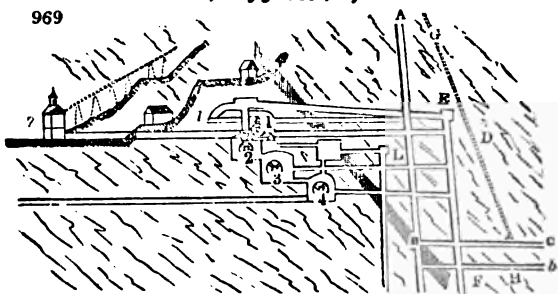
Fig. 968. is a section of the mines of Kiegelsdorf in Hessa, presenting —

1. Vegetable mould.
2. Limestone distinctly stratified, frequently of a yellowish colour, called *lagerhafter kalkstein*.
3. Clay, sometimes red, sometimes blue, sometimes a mixture of red, blue, and yellow.
4. The cellular limestone (*rauhkalk*). This rock differs both in nature and position from the rock of the same name at Mansfeldt.
5. Clay, usually red, containing veins of white gypsum, and fine crystals of selenite.
6. Massive gypsum of recent formation
7. Fetid limestone, compact and blackish gray, or cellular and yellowish gray.
8. Pulverulent limestone, with solid fragments interspersed.
9. Compact marl-limestone, or *zechstein*, which changes from a brownish colour above to a blackish schist below, as it comes nearer the cupreous schist, which seems to form a part of it.
10. Cupreous schist (*kuperschiefer*), of which the bottom portion, from 4 to 6 inches thick, is that selected for metallurgic operations. Beneath it, is found the usual wall or bed of sandstone. A vein of cobalt ore a, which is rich only in the grayish-white sandstone (*weisse liegende*), traverses and deranges all the beds wherever it comes.

Of working mines by fire. — The celebrated mine worked since the tenth century in the mountain called *Rammelsberg*, in the Hartz, to the south of Goslar, presents a stra-

tified mass of ores, among the beds of the rock which constitute that mountain. The mineral deposit is situated in the earth, like an enormous inverted wedge, so that its thickness (power), inconsiderable near the surface of the ground, increases as it descends. At about 100 yards from its outcrop, reckoning in the direction of the slope of the deposit, it is divided into two portions or branches, which are separated from each other, throughout the whole known depth, by a mass of very hard clay slate, which passes into flinty slate. The substances composing the workable mass are copper and iron pyrites with sulphuret of lead (galena), accompanied by quartz, carbonate of lime, compact sulphate of baryta, and sometimes gray copper ore, sulphuret of zinc, and arsenical pyrites. The ores of lead and copper contain silver and gold, but in small proportion, particularly as to the last.

A mine so ancient as that of Rammelsberg, and which was formerly divided among several adventurous companies, cannot fail to present a great many shafts and excavations; but out of the 15 pits, only two are employed for the present workings; namely, those marked Δ and Σ and Σ Γ , in *fig.* 969., by which the whole extraction and



drainage are executed. — The general system of exploitation by fire, as practised in this mine, consists of the following operations: —

1. An advance is made towards the deposits of ore, successively at different levels, by transverse galleries which proceed from the shaft of extraction, and terminate at the wall of the stratiform mass.
2. There is formed in the level to be worked, large vaults in the heart of the ore, by means of fire, as we shall presently describe.
3. The floor of these vaults is raised up by means of terraces formed from the rubbish, in proportion as the roof is scooped out.
4. The ores detached by the fire from their bed, are picked and gathered; sometimes the larger blocks are blasted with gunpowder.
5. Lastly, the ores thus obtained are wheeled towards the shaft of extraction, and turned out to the day.

Let us now see how the excavation by fire is practised; and in that view, let us consider the state of the workings in the mines of Rammelsberg in 1809. We may remark in *fig.* 969. the regularity of the vaults previously scooped out above the level a c , and the other vaults which are in full activity of operation. It is, therefore, towards the lower levels that the new workings must be directed. For this purpose, the transverse gallery being already completed, there is prepared on the first of these floors a vault of exploitation at b , which eventually is to become similar to those of the superior levels. At the same time, there is commenced at the starting point below it, reached by a small well dug in the line of the mineral deposit, a transverse gallery in the rock, by means of blasting with gunpowder. The rock is also attacked at the starting-point by a similar cut, which advances to meet the first perforation. In this way, whenever the vaults of the level c are exhausted of ore and terraced up with rubbish, those of the level beneath it will be in full activity.

Others will then be prepared at a lower level; and the exploitation may afterwards be driven below this level by pursuing the same plan, by which the actual depth of excavation has been gained.

In workings by fire we must distinguish, 1. The case where it is necessary to open a vault immediately from the floor; 2. The case where the vault having already a certain elevation, it is necessary to heighten its roof. In the former case, the wall or floor of the mineral deposit is first penetrated by blasting with gunpowder. As soon as this penetration is effected over a certain length, parallel to the direction of the future vault, as happens at b , there is arranged on the bottom a horizontal layer of billets of firwood, over which other billets are piled in nearly a vertical position, which rest upon the ore, so that the flame in its expansion comes to play against the mineral mass to be

detached. When after some similar operations, the flame of the pile can no longer reach the ore of the roof on account of its height, a small terrace of rubbish must be raised on the floor of the deposit; and over this terrace, a new pile of faggots is to be heaped up as above described. The ancient miners committed the fault of constantly placing such terraces close to the roof, and consequently arranging the faggots against this portion of the ore, so that the flame circulated from the roof down to the floor. The result of such procedure was the weakening of the roof, and the loss of much of the ore which could not be extracted from so unstable a fabric; and besides, much more wood was burned than at the present day, because the action of the flame was dissipated in part against the whole mass of the roof, instead of being concentrated on the portion of the ore which it was desired to dislodge. Now, the flame is usually made to circulate from the floor to the roof, in commencing a new vault.

When the vault has already a certain height, care is always taken that between the roof of the vault and the rubbish on which the pile is arranged, no more than two yards of space should intervene, in order that the flame may embrace equally the whole concavity of the vault, and produce an uniform effect on all its parts. Here, the pile is formed of horizontal beds, disposed crosswise above one another, and presents four free vertical faces, whence it has been called a *chest* by the miners.

It is usually on Saturday that the fire is applied to all the piles of faggots distributed through the course of the week. Those in the upper floors of exploitation are first burned, in order that the inferior piles may not obstruct by their vitiated air, the combustion of the former. Thus, at 4 o'clock in the morning, the fires are kindled in the upper ranges; from pile to pile, the fireman and his assistant descend towards the lower floors, which occupies them till 3 o'clock in the afternoon. Vainly should we endeavour to describe the majestic and terrific spectacle which the fire presents, as it unfolds its wings under its metallic vaults, soon filled with vast volumes of smoke and flame. Let us mark the useful effect which it produces.

When the flame has beat for a few instants on the beds of ore, a strong odour of sulphur, and sometimes of arsenic is perceived; and soon thereafter loud detonations are heard in the vaults. Suddenly the flame is seen to assume a blue colour, or even a white; and at this period, after a slight explosion, flakes of the ore, of greater or less magnitude, usually fall down on the fire, but the chief portion of the heated mineral still remains fixed to the vault. The ores pass now into a shattered and divided condition, which allows them afterwards to be detached by long forks of iron. In this manner the fire, volatilizing entirely some principles, such as sulphur, zinc, arsenic, and water, changing the aggregation of the constituent parts of the ore, and causing fissures by their unequal expansibilities, facilitates the excavation of such materials as resist by their tenacity the action of gunpowder.

The combustion goes on without any person entering the mine from Saturday evening till Monday morning, on which day, the fireman and his assistants proceed to extinguish the remains of the bonfires. On Monday also some piles are constructed in the parts where the effect of the former ones has been incomplete; and they are kindled after the workmen have quitted the mine. On Tuesday all hands are employed in detaching the ores, in sorting them, taking them out, and preparing new piles against the next Saturday.

The labour of a week consists for every man of five posts during the day, each of 8 hours, and of one post of four hours for Saturday. Moreover, an extra allowance is made to such workmen as employ themselves some posts during the night.

The labour of one compartment or *atelier* of the mine consists therefore in arranging the faggots, in detaching the ore which has already experienced the action of the fire, in breaking the blocks obtained, in separating the ore from the *debris* of the pile, and whenever it may be practicable or useful, in boring holes for blasting with gunpowder. The heat is so great in this kind of mine, that the men are obliged to work in it without clothing.

We have already remarked, that besides the working by fire, which is chiefly used here, recourse is sometimes had to blasting by gunpowder. This is done in order either to recover the bottom part or ground of the vaults on which the fire can act but imperfectly, to clear away some projections which would interfere with the effect of the pile, or lastly to strip the surrounding rock from the mass of the ore, and thence to obtain schist proper for the construction of the rubbish-terraces.

The blasting process is employed when the foremen of the workshop or mine-chamber judge that a hole well placed may separate enough of ore to pay the time, the repair of tools, and the gunpowder expended. But this indemnification is rarely obtained. The following statement will give an idea of the tenacity which the mineral deposit often presents.

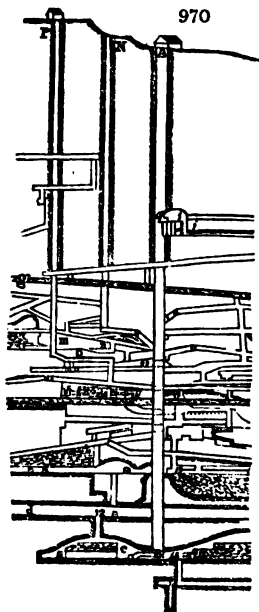
In 1808, in a portion of the Rammelsberg mine, the ore, consisting of extremely compact iron and copper pyrites, was attacked by a single man, who bored a mining hole.

After 11 posts of obstinate labour, occupying altogether 88 hours, the workman, being vigilantly superintended, had been able to advance the hole to a depth of no more than 4 inches; in doing which he had rendered entirely unserviceable 126 punches or borers, besides 26 others which had been re-tipped with steel, and 201 which had been sharpened; 6½ pounds of oil had been consumed in giving him light; and half a pound of gunpowder was required for blasting the bore. It was found from a calculation made upon these facts by the administration of mines, that every inch deep of this hole cost, at their low price of labour, nearly a florin, value two shillings and sixpence.

It is therefore evident that though the timber, of which the consumption is prodigiously great, were much less abundant and dearer than it still is at Rammelsberg, mining by fire would be preferable to every other mode of exploitation. It is even certain, that on any supposition, the employment of gunpowder would not be practicable for every part of the mine; and if fuel came to fail, it would be requisite to renounce the workings at Rammelsberg, although this mountain still contains a large quantity of metals.

If in all mines the free circulation of air be an object of the highest importance, we must perceive how indispensable it must be in every part of a mine where the mode of exploitation maintains the temperature of the air at 112° Fahr., when the workmen return into it after the combustion of the piles, and in which besides it is necessary that this combustion be effected with activity in their absence. But in consequence of the extent and mutual ramifications of the workings, the number of the shafts, galleries, and their differences of level, the ventilation of the mine is in a manner spontaneously maintained. The high temperature is peculiarly favourable to it. The aid of art consists merely in placing some doors judiciously, which may be opened or shut at pleasure, to carry on the circulation of the air.

In considering the Rammelsberg from its summit, which rises about 400 yards above the town of Goslar, we observe, first, beds of slaty sandstone, which become the more horizontal the nearer they approach to the surface. At about 160 yards below the top level there occurs, in the bosom of the slaty graywacke, a powerful stratum of shells impasted in a ferruginous sandstone. See D, *fig.* 963. In descending towards the



face of the ore, the parallel stratification of the clay-slate which forms its walls and roof grows more and more manifest. Here the slate is black, compact, and thinly foliated. The inclination of the different beds of rock is indicated at *a*. The substance of the workable mass is copper and iron pyrites, along with sulphuret of lead, accompanied by quartz, carbonate of lime, compact sulphate of baryta, and occasionally gray copper (*fahlerz*), sulphuret of zinc, and arsenical pyrites.

The ores are argentiferous and auriferous, but very slightly so, especially as to the gold. It is the ores of lead and copper which contain the silver, and in the latter the gold is found, but without its being well ascertained in what mineral it is deposited. Sometimes the copper occurs in the native state, or as copper of cementation. Beautiful crystals of sulphate of lime are found in the old workings.

In *figs.* 969, 970., *A B* is the shaft of extraction, called the *Kahnenkuhler*; *x* is the ventilation shaft, called *Breilingerwetterschacht*; *r* is the extraction shaft, called *Janier-schacht*.

x r, is a new extraction-shaft, called *Neuer treibschacht*, by which also the water is pumped up; by *A B*, and *x r*, the whole extraction and draining are carried on. The ores are raised in these shafts to the level of the wagon-gallery (*galerie de roulage*) *i*, by the whims *1, q*, provided with ropes and buckets. *1, 2, 3, 4, fig.* 969., represent the positions of four water-wheels for working the whims; the first two being employed in extracting the ores, the last two in draining. The driving stream is led to the wheel *1*, along the drift *l*; whence it falls in

succession upon the wheels *2, 3, 4*. The general system of working consists of the following operation:—

1. The bed of ore is got at by the transverse galleries, *m, n, o, q, s*, which branch off from the extraction shaft, and terminate at the wall of the main bed;
2. Great vaults are scooped out at the level of the workings, by means of fire;

2. Great vaults are scooped out at the level of the workings, by means of fire;
3. The roofs of these vaults are progressively propped with mounds of rubbish;
4. The ores thus detached, or by blasting with gunpowder, are then collected;
5. Lastly, they are wheeled out to the day; and washed near z.

COMPARATIVE TABLE of celebrated MINES in EUROPE and AMERICA. By F. BURT, Esq.
(Quarterly Mining Review for July, 1835, p. 60.)

| | CONSOLIDATED AND UNITED MINES. (At present the richest mines in Cornwall.) | VEVA GRANDE MINES. (At present the richest mines in Mexico.) | MINE OF VALENCIANA. (Richest of the Mexican mines at the beginning of the present century.) | MINE OF FREYBERG. (Richest of the Saxon mines at the beginning of the present century.) |
|--|---|---|---|---|
| Situation | Two miles east of Redruth. | Four miles north of Zacatecas. | One mile north of Guanaxtato. | Two miles south-east of Freyberg. |
| Elevation | Elevation of the surface above the level of the sea, from 200 to 300 ft.; depth of the bottom of the mine below the level of the sea, about 1,370 feet. | Elevation of the surface above the level of the sea, supposed to be about 6000 feet. Elevation of the bottom of the mine above the level of the sea, probably near 5,000 feet. | Elevation of the surface above the level of the sea, 7,617 feet. Elevation of the bottom of the mine above the level of the sea, 5,730 feet. | Elevation of the surface above the level of the sea, 1,546 feet. Elevation of the bottom of the mine above the level of the sea, 863 feet. |
| Nature of the rock | Primary clay slate resting immediately on granite, a short distance westward of the mines. The clay slate is intersected by numerous channels of porphyry, which have nearly the same direction as the mineral veins, and are often of considerable width. The porphyry sometimes appears also to form large irregular masses in the clay slate. Both rocks are traversed by veins of quartz and clay intersecting the metalliferous veins. | Transition clay slate, alternating with dolomite, and occasionally with greywacke. This clay slate is sometimes decomposed; it rests on syenitic rocks, and is in some places covered with porphyry. | The <i>Veta Madre</i> of Guanaxtato, upon which this mine is worked, traverses both clay slate and porphyry, but it is most productive in the former rock. The clay slate is considered by Humboldt to belong to the transition class, but situated near the limits of primary formations. This rock in depth, passes into chlorite slate, and talc slate. It contains subordinate beds of syenite, hornblende slate, and serpentine. The porphyry rests upon the clay slate, and is conformable to it, both in direction and stratification. | The rock prevailing in the neighbourhood of Freyberg, in which this and most of the other mines are situated, is a formation of primary gneiss. |
| Nature of the metalliferous deposits | In the consolidated mines, the eight following lodes are extensively worked:—Wheal Fortane lode, Cuesven lode, Double's lode, Old lode, Taylor's lode, Trengoon's lode, Martin's lode, and Giever's lode. In the united mines, the principal workings are upon the Old lode, and about five or six others are more or less productive. Numerous smaller lodes or "branches" occur also in both mines. The principal lodes are from 2 or 5, to 7 or 8 feet wide; the "branches" are generally 12 or 18 inches wide. The direction of the lodes varies from nearly east and west to about 20 degrees north of east and south of west. The underlie of the principal lodes, is from 2 to 3 feet per fathom north, that of the smaller ones about the same south. | One principal vein (the <i>Veta Grande</i>) which is generally separated into three branches, and sometimes into four. When ramified, the width extends to 60 or 70 feet; when united, it varies from 8 or 10 to 20 or 30 feet. The branches are generally about 10 or 12 feet wide, and the upper one is most productive. The direction of the <i>Veta Grande</i> , is from 30 to 40 degrees south of east, and north of west, and its underlie, from two to three feet per fathom south. Other veins of less size, occur in the neighbourhood of the <i>Veta Grande</i> , which cross it at an acute angle. One of these appears to bear the vein for about 700 feet, being the most remarkable derangement of the kind on record. | One <i>Veta</i> (the <i>Veta Madre</i>) which is often separated into three branches, extending from 130 to 160 feet in width. When not ramified, its width varies from 20 or 30 to 60 or 70 feet, but is more commonly from 40 to 50 feet. The direction of the vein, is north-west and south-east; its underlie is south, and about five or six feet per fathom. | There are five veins worked in this mine. The principal vein (<i>Frick-Jacke</i>) is from one foot six inches, to three feet in width, the others are from six to 12 inches wide. The direction of this vein, is nearly north and south, its underlie is west, and about three feet per fathom. Some of the other veins intersect it. |
| Ores | Chiefly copper ore, occasionally native copper, blue and green carbonate of copper. Tin, or oxide of tin, also occurs, but not in very great abundance. | Chiefly red silver, native silver, sulphuret of silver, and argentiferous pyrites. | Sulphuret of silver, native silver, prismatic black silver, red silver, native gold, argentiferous gossans. | Argentiferous sulphuret of lead, native silver, sulphuret of silver, red silver. |
| Produce of the ores | 94 per cent. of fine copper; average produce in 100 parts of ore. | 24 oz. per quintal. | Four ounces of silver per equivalent of 100 lbs., equivalent to 2½ parts of metal in 1,000 of ore, or ¼ per cent. | Six to seven ounces of silver per quintal of 100 lbs. Equivalent to from 54 to 43 parts of metal in 1,000 of ore, or from 5-5ths to nearly ½ per cent. |
| Veinstone | Chiefly quartz, of which many varieties occur. | Chiefly quartz, occasionally amethyst, carbonate of lime, and sulphate of barytes. | Quartz, amethyst, carbonate of lime, pearlespar, and hornstone. | Quartz, pearispar, and calcareous spar. |
| Mineral substances accompanying the ores | The ores are generally accompanied by "gossan" in the licks of the lodes, by blende, and by iron and arsenical pyrites in depth. | The ores are generally accompanied by blende, sulphuret of antimony, and iron pyrites. | The ores are accompanied by blende, spathose iron, copper and iron pyrites. | The ores are accompanied by blende, spathose iron, and a little iron and arsenical pyrites. |
| Depth of the principal shafts | <i>Wheal's engine shaft</i> , 248 fathoms; <i>Feary's engine shaft</i> , 275 fathoms. Some of the other engine shafts are scarcely inferior in depth. | <i>Tiro General</i> , 188 fathoms; <i>Gallega shaft</i> , 138 fathoms. | <i>Tiro General</i> , 310 fathoms. | <i>Frankenschack</i> , 180 fathoms. |

• Gossan, or Gossan; oxide of iron and quartz.

COMPARATIVE TABLE of celebrated MINES in EUROPE and AMERICA.
By F. Burr, Esq. — *Continued.*

| | CONSOLIDATED AND UNITED MINES. (At present the richest mines in Cornwall.) | VETA GRANDE MINES. (At present the richest mines in Mexico.) | MINES OF VALENCIANA. (Richest of the Mexican mines at the beginning of the present century.) | MINES OF HUANILLAPURTO. (Richest of the Mexican mines at the beginning of the present century.) |
|---|--|---|---|---|
| Depth of adit at the principal shafts | At Woolf's engine-shaft, 12 fathoms. The average depth of the adit at the other engine-shafts is about 30 or 40 fathoms. | There is no adit to this mine. | There is no adit to this mine. | The adit at the shaft called <i>Praxomoteles</i> , is 47 fathoms in depth. |
| Quantity of water | Varies from 3,000 to 5,000 gallons per minute. | About 80 gallons per minute. | The Valenciana was a dry mine from its commencement in 1760 to 1780, when it first became troubled with water, in consequence of some of the workings being inadvertently communicated with the adjoining mine of Tepeyac; which, although upon the same vein, was extremely wet. The quantity of water raised during the late working appears to have been about 110 gallons per minute, but the regular influx was much less. | 50 gallons per minute. |
| Height to which the water is raised | About 230 fathoms at the consolidated mines, at the united mines, about 110 fathoms. | On an average about 150 fathoms. | 310 fathoms. | 133 fathoms. |
| Power employed in drainage | 9 steam-engines; 3 of 90-inch cylinder, 3 of 85, 1 of 80, and 2 of 65. A water wheel, 48 feet in diameter. | Usually 10 malacates.* | A steam-engine of 30-inch cylinder, and 7 malacates. | Two water-wheels, each 42 feet in diameter. |
| Probable equivalent in actual horse-power | 1,500 constantly at work, or a total number of above 4,500. | 32 horses constantly at work, or a total number of about 100 horses. | 65 horses constantly at work, or a total number of about 300. | 16 horses constantly at work, or a total number of about 50. |
| Average annual expense in drainage | 12,700 <i>l.</i> , taking the average of the last ten years. | 20,000 <i>l.</i> per annum. | About 40,000 <i>l.</i> per annum. | Cannot be ascertained, but evidently very small. |
| Quantity of ore annually produced | 16,400 tons of copper ore, a few tons of tin ore. | 31,380 tons of silver ore. | 32,500 tons of silver ore. | 630 tons of silver ore. |
| Produce in metal | 1,517 tons of fine copper, a little tin. | 153,000 lbs. troy of silver. | 221,900 lbs. troy silver. | 6,120 lbs. troy of silver. |
| Total returns, or value of the above. | 119,500 <i>l.</i> | 23,400 <i>l.</i> per annum. | About 600,000 <i>l.</i> | About 18,000 <i>l.</i> |
| Total costs of the mine | 35,500 <i>l.</i> exclusive of lord's dues; 198,500 <i>l.</i> including lord's dues. | 252,170 <i>l.</i> per annum. | 197,900 <i>l.</i> per annum. | 9,500 <i>l.</i> per annum. |
| Clear profit to the proprietors | 21,000 <i>l.</i> per annum. | 171,840 <i>l.</i> per annum. | 118,750 <i>l.</i> per annum. | 3,560 <i>l.</i> per annum. |
| Amount of capital invested | 75,000 <i>l.</i> | 130,000 <i>l.</i> | Cannot be ascertained, but known to have been very small. | Cannot be ascertained, but probably very small. |
| Interest on capital invested | 380 per cent. after paying back the original capital. | Nearly 700 per cent. after paying back the original capital. | Not known, but certainly many hundred per cent. | Not known, but probably very high. |
| Proportion of cost to returns | (Cost exclusive of lord's dues, 78 per cent.) | About 59 per cent. | Costs 50 per cent. In the nine years following, the proportion was 80 per cent., at the end of that time the working of the mine was stopped by the revolution, in the year 1809. | Costs 73 per cent. |
| Number of men employed | About 2,500 persons, of whom about 1,450 are employed under ground. | About 900, of whom nearly 600 are employed under ground. | 3,100 Indians and Mestizos, of whom 1,800 are employed under ground. | 700 miners of whom 550 are employed under ground. |
| Wages of the mines per day | Probably about 3 shillings on an average. | About 8 or 9 shillings per day. | From 4 to 5 shillings. | About 1 <i>l.</i> 6 <i>s.</i> per day. |
| Quantity and expense of powder | Sold to the smelting companies, and smelted by them at Swansea, in South Wales. | Chiefly reduced by the company at the hacienda of Sancocha, by smelting and amalgamation. | Sold to the <i>Rancho de Sancocha</i> , and reduced by smelting and amalgamation at hacienda, in the neighbourhood of Usmanarato. | 240 cwt.; value 1,070 <i>l.</i> |
| Manner in which the ore are disposed of | | | | Delivered to the Government, reduction works in the neighbourhood of Freiberg, where they are partly smelted, and partly amalgamated. |

VENTILATION OF MINES.

When men penetrate by narrow passages into the interior of the earth, their respiration, joined to the combustion of candle and gunpowder, are not long of vitiating the air. The decomposition of wood contributes to the same effect, as also the mineral bed itself, especially in coal mines, by the carburetted hydrogen and carbonic acid evolved, and from the absorption of oxygen by pyrites. In many cases, arsenical and mercurial vapours are disengaged. Hence the necessity of maintaining in sub-

* Malacate; a horse whim.

terranean cavities a continual circulation of air, which may renew the atmosphere round the miners. The whole of the means employed to produce this effect constitutes what is called the *ventilation of mines*.

These means are divided into *natural* and *artificial*. The *natural means* are the currents produced by the difference of density between the air of mines and the external air; the *artificial* are air-exhausters or condensers, fires, &c.

The temperature of the air of the subterranean workings surpasses the mean temperature of the place in which the mine is opened. Hence it is lighter in winter, but in summer often heavier than the air of the atmosphere. For this reason, when the mine presents two openings at different levels, the air naturally flows out by the most elevated in winter, and by the lowest in summer. We may take advantage of this circumstance, to lead the air into the bottom of even a very long gallery, opening into the side of the mountain, by piercing a shaft into its roof at some distance from the entrance and dividing the gallery by a horizontal floor into two parts, which have no mutual communication, except at the furthest extremity—the upper part communicating with the shaft, and the under with the mouth of the gallery. If the two compartments have different dimensions, the air in the smaller sooner comes into an equilibrium of temperature with the rock; and the difference of temperature of the two compartments is sufficient to produce a current. If a streamlet of water flows through this gallery, it facilitates the flow of the air along the lower compartment. If a mine has several openings situated on the same level, it rarely happens but some peculiar circumstance destroys, during the colds of winter and the heats of summer, the equilibrium of the air. But in spring and autumn, when the external air is nearly of the same temperature with that of the mines, the above-named causes are almost always too feeble to excite an issuing current. This effect is, however, frequently obtained by raising over one of the shafts a chimney 20 or 30 yards high, which alone produces the effect of an opening at a different level. It has been remarked that stormy weather usually deranges every system of ventilation. See *BITUMEN AND VENTILATION*.

MINES, BLASTING. It has been often noticed that since the application of gunpowder for blasting, few if any improvements have been made in the methods adopted for cutting through hard rocks; and the great expense of maintaining engine power for pumping and winding during the long period required to sink shafts through such rocks has been and still is the sole cause of some of the best and richest tracts of minerals in Great Britain lying idle and unproductive, and has been the principal cause of the loss of life so serious and often occurring from explosion in mines.

The improvements, or rather the new system now introduced, will be better understood after a review of the methods and tools heretofore used.

The oldest method of pumping, or taking up the water from the bottom of the shaft during sinking was the Hogar pipe; this was about 4 feet in length, made of leather, and stiffened by rings of metal: the constant damage this was liable to in blasting caused it to be almost abandoned, and in its place the stock and slide pipe was introduced. This consists of two cast-iron pipes sliding into each other as a telescope and kept tight in the joint by a stuffing-box; this contrivance is not only expensive in first cost, but liable to breakage and heavy to handle. Both these modes of pumping are subject to a still greater defect; the pump can only be made nearly under the pump trees, so that during a long time of the sinking it often occurs that only two or three men can be effectually employed in the shaft; this in some of the large shafts (say on a common size used in South Wales, 18 feet by 10 feet) causes serious delay in the progress of the work.

In boring it has been customary to use a borer, the body of which was made of wrought iron, and the bit or end of the borer of shear steel welded on the iron. No attempts appear ever to have been made to fix any definite proportion between the size of the stock or handle and the breadth of the bit; and from this cause a very great portion of the power of the striker has been uselessly expended.

The use of cast steel borers is, in some respects, entirely new as applied to mining, and by the superior hardness of cast steel as compared with shear steel, greatly expedites the process of boring and saves expense; they have also an advantage in transmitting the force of the hammer to the bit, on account of their stiffness or rigidity; and further to prevent loss of power, it is of importance that the bit should be so proportioned to the handle or stock as to work freely in the bore-hole, and at the same time spring or bend as little as possible under the blow of the hammer. The following proportions appear to answer these conditions. (See top of next page.)

The suction pipe now used by the exhibitor, about 20 feet in length, is made of gutta percha, and supersedes the use of the leather Hogar and the stock and slide; it is not liable to accident, and can be repaired easily; it enables the pump slide to be made in any part of the shaft, and a greater number of men to work it in the shaft at one time.

| Diameter of Octagon Cast Steel. | Breadth of the face of Bit. |
|------------------------------------|--------------------------------|
| 1 inch. | 1½ inch. |
| 1¼ " | 1¾ " |
| 1½ " | 2 " |
| 1¾ " | 2¼ " |
| 1⅞ " | 2½ " |

The introduction of electricity as the power for blasting in connection with the improvements before explained, may be said to constitute a new era in the history of mining.

The apparatus at present used for blasting is Grove's battery of 6 inches square: this is placed in some convenient position near the top of the shaft; two copper wires, coated with gutta percha, are carried down the shafts, and these are connected with the other wires inserted in a small cartridge which is placed in the charge of powder for blasting.

MINES. The miner, in sinking into the earth, soon opens up numerous springs, whose waters, percolating into the excavations which he digs, constitute one of the greatest obstacles that nature opposes to his toils. When his workings are above the level of some valley and at no great distance, it is possible to get rid of the waters by leading them along a *trench* or a *gallery of efflux*. This forms always the surest means of drainage; and notwithstanding the great outlay which it involves, it is often the most economical. The great advantages accruing from these galleries, lead to their being always established, and without risk, in mines which promise a long continuance. There are many galleries several leagues in length; and sometimes they are so contrived as to discharge the waters of several mines, as may be seen in the environs of Freyberg. Merely such a slope should be given them as is barely sufficient to make the water run, at the utmost from $\frac{1}{100}$ to $\frac{1}{200}$ so as to drain the mine to the lowest possible level.

Whenever the workings are driven below the natural means of drainage, or below the level of the plain, recourse must be had to mechanical aids. In the first place, the quantity of percolating water is diminished as much as possible by planking, walling, or caulking-up with the greatest possible care those pits and excavations which traverse the water levels; and the lower workings are so arranged that all the waters may unite into wells placed at the bottom of the shafts or inclined galleries; whence they may be pumped up to the day, or to the level of the *gallery of efflux*. In most mines, simple sucking pumps are employed, because they are less subject to give way, and more easy of repair; and as many of these are placed over each other, as the shaft is ten yards deep, below the point where the waters have a natural run.

These draining machines are set in motion by that mechanical power which happens to be least costly in the place where they are established. In almost the whole of England, and over most of the coal mines of France and Silesia, the work is done by steam engines; in the principal metallic mines of France, and in almost the whole of Germany and Hungary, by hydraulic machines; and in other places, by machines moved by horses, oxen, or even by men. If it be requisite to lift the waters merely to the level of a *gallery of efflux*, advantage may be derived from the waters of the upper parts of the mine, or even from waters turned in from the surface, in establishing in the mine of the gallery-level, water-pressure machines, or overshot water-wheels, for pumping up the lower water. This method is employed with success in several mines of Hungary, Bohemia, Germany, Derbyshire, Cornwall, in those of Poullaouen in Brittany, &c. It has been remarked, however, that the copious springs are found rather towards the surface of the soil than in the greatest depths.

TRANSPORT OF ORES TO THE SURFACE.

The ore being extracted from its bed, and having undergone, when requisite, a first sorting, it becomes necessary to bring it to the day, an operation performed in different ways according to circumstances and localities, but too often according to a blind routine. There are mines at the present day, where the interior transport of ore is executed on the backs of men; a practice the most disadvantageous possible, but which is gradually wearing out. The carriage along galleries is usually effected by means of hurdles, barrows, or, still better, by little waggons. These consist of frames resting on four wheels; two larger, which are placed a little behind the centre of gravity, and two smaller, placed before it. When this carriage is at rest, it bears on its four wheels, and leans forwards. But when the miner, in pushing it before him, rests on its posterior border, he makes it horizontal; in which case it rolls only upon the two larger wheels. Thus, the friction due to four wheels is avoided, and the roller or driver bears no part of the burden, as he would do with ordinary wheelbarrows. To ease the draught still more, two parallel rails of wood or iron are laid along the floor of the gallery, to which

the wheels of the carriage are adjusted. It is especially in metallic mines, where the ore is heavy, and the galleries straight, that these peculiar waggons are employed. In coal mines, carriages formed with a much larger basket, borne on a rail-road by four equal wheels, are preferred. Sometimes the above wain, called on the Continent a *dog* (*chien*), is merely a simple frame on four wheels, on which a basket is set. In the great mines, such as many of the coal and salt mines of Great Britain, the salt mines of Galicia, the copper mines of Fahlun, the lead mines of Alston-Moor, horses and asses are introduced into the workings to drag heavier waggons, or rather a train of waggons attached to one another. These animals often live many years under ground, without ever revisiting the light of day. In other mines, such as those of Worsley, in Lancashire, subterranean canals are cut, upon which the ore is transported in boats.

When the workings of a mine are beginning, when they are still of little depth, and employ few hands, it is sufficient to place over the shaft a simple wheel and axle, by means of which a few men may raise the water pails, and the baskets or tubs filled with ore; but this method becomes soon inadequate, and should be replaced by more powerful machines.

ACCESSORY DETAILS.

Few mines can be penetrated entirely by means of galleries. More usually there are shafts for mounting and descending. In the pits of many mines, the workmen go down and come up by means of the machines which serve to elevate the ores. In several mines of Mexico, and the north of Europe, pieces of wood, fixed on each side of the pit, form the rude steps of a ladder by which the workmen pass up and down. In other mines, steps are cut in the rock or the ore; as in the quicksilver mines of Idria and the Palatinat, in the salt mines of Wieliczka, and in some of the silver mines of Mexico. In the last they serve for the transport of the ore, which is carried up on men's backs. Lastly, certain mines are entered by means of slopes, some of which have an inclination of more than 30°. The workmen slide down these on a kind of sledge, whose velocity of descent they regulate by a cord firmly fixed at the upper end.

Miners derive light from candles or lamps. They carry the candles in a lump of soft clay, or in a kind of socket terminated by an iron point, which serves to fix it to the rock, or to the timbering. The lamps are made of iron, hermetically closed, and suspended, so that they cannot droop, or invert, and spill the oil. They are usually hung on the thumb by a hook. Miners also employ small lanterns, suspended to their girdles. Many precautions and much experience are requisite to enable them to carry these lights in a current of air, or in a vitiated atmosphere. It is especially in coal mines liable to the disengagement of carburetted hydrogen, that measures of safety are indispensable against the explosions. The appearance of any halo round the flame should be carefully watched as indicating danger; and the lights should be carried near the bottom of the gallery. The great protector against these deplorable accidents, is the safety lamp. See LAMP OF DAVY.

We cannot conclude this general outline of the working of mines, without giving some account of the miners. Most men have a horror at the idea of burying themselves, even for a short period, in these gloomy recesses of the earth. Hence mining operations were at first so much dreaded, that, among the ancients, they were assigned to slaves as the punishment of their crimes. This dislike has diminished with the improvements made in mining; and, finally, a profitable and respected species of labour has given mining its proper rank among the other departments of industry. The *esprit de corps*, so conspicuous among seamen, has also arisen among miners, and has given dignity to their body. Like every society of men engaged in perilous enterprises, and cherishing the hopes of great success, miners get attached to their profession, talk of it with pride, and eventually in their old age regard other occupations with contempt. They form, in certain countries, such as Germany and Sweden, a body legally constituted, which enjoys considerable privileges. Miners work usually 6 or 8 hours at a time. This period is called a *journey* (*poste*, in French).

Miners wear, in general, a peculiar dress, the purpose of which is to protect them, as much as possible, from the annoyances caused by water, mud, and sharp stones, which occur in the places where they work. One of the most essential parts of the dress of a German miner is an apron of leather fitted on behind, so as to protect them in sitting on moisture or angular rubbish. In England, the miners wear nothing but flannels; though they frequently strip off all their clothes, except their trowsers. In many countries the mallet and the pick, or *pointierolle* (called in German, *Schegel* and *Eisen*), disposed in a Saint Andrew's cross, are the badge of miners, and are engraved on their buttons, and on every thing belonging to mines.

Several of the enterprises executed in mines, or in subserviency to them, merit a distinguished rank among the history of human labours. Several mines are worked to a depth of more than 600 yards, some even to a thousand yards below the surface of the

soil. A great many descend beneath the level of the ocean; and a few even extend under its billows, and are separated from them by a thin partition of rock, which allows their noise, and the rolling of the pebbles, to be heard.

In 1792, there was opened, at Valenciana, in Mexico, an octagonal pit, fully $7\frac{1}{2}$ yards wide, destined to have a depth of 560 yards, to occupy 23 years in digging, and to cost 240,000*l*.

The great drainage gallery of the mines of Clausthal, in the Hartz, is 11,377 yards, or $6\frac{1}{2}$ miles long, and passes upwards of 300 yards below the church of Clausthal. Its excavation lasted from the year 1777 till 1800, and cost about 66,000*l*. Several other galleries of efflux might also be adduced, as remarkable for their great length and expense of formation.

The coal and iron mines subservient to the iron works of Mr. Crawshaw, at Merthyr-Tydvil, in Wales, have given birth to the establishment interiorly and above ground, of iron railways, whose total length, many years ago, was upwards of 100 English miles.

The carriage of the coal extracted from the mines in the neighbourhood of Newcastle to their points of embarkation, is executed almost entirely, both under ground and on the surface, on iron railways, possessing an extent of upwards of 500 miles.

There is no species of labour which calls for so great a development of power as that of mines; and accordingly, it may be doubted if man has ever constructed machines so powerful as those which are now employed for the working of some mineral excavations. The waters of several mines of Cornwall are pumped out by means of steam engines, whose force is equivalent, in some instances, to the simultaneous action of many hundred horses.

MINES, GENERAL SUMMARY OF.

Mines may be divided into three great classes: 1. Mines in the geological formations anterior to the coal strata; 2. Mines in the secondary formations; 3. Mines in alluvial districts.

The first are opened, for the most part, upon veins, masses, and metalliferous beds.

The second, on strata of combustibles, as coal; and metalliferous or saliferous beds.

The last, on deposits of metallic ores, disseminated in clays, sands, and other alluvial matters, usually superior to the chalk; and even of far more recent formation.

The mines of these three classes, placed, for the most part, in very different physical localities, differ no less relatively to the mode of working them, and their mechanical treatment, than in a geological point of view.

MINES OF FORMATIONS ANTERIOR TO THE COAL.

These mines are situated in a few mountainous regions, and their whole amount forms but a small portion of the surface of the earth. The most remarkable of these are:—The Cordilleras of South America; the mountains of Hungary; the Altayan mountains; the Ural mountains; the Vosges and the Black Forest; the Harz, and the east of Germany; the centre of France; the north of Portugal, and the adjacent portions of Spain; Brittany; the corresponding coasts of Great Britain and Ireland; the north of Europe; the Alleghany chain; the south of Spain; the Pyrenees; the Alps; the schistose districts on the banks of the Rhine and the Ardennes; the calcareous mountains of England and of Daouria.

MINES OF THE CORDILLERAS OF SOUTH AMERICA.

Few regions are so celebrated for their mineral wealth as the great chain which, under the name of the Cordillera of the Andes, skirts the shores of the Pacific ocean, from the land of the Patagonians to near the north-west point of the American continent. Who has not heard of the mines of Mexico and Potosi? The mineral wealth of Peru has passed into a proverb.

The most important mines of the Cordilleras are those of silver; but several of gold, mercury, copper, and lead, have likewise been opened. These mountains are not equally metalliferous in their whole extent. The workings occur associated in a small number of districts far distant from each other.

In the Andes of Chili, particularly in the province of Coquimbo, some silver mines are explored, which afford chiefly ores of an earthy or ferruginous nature, mingled with imperceptible portions of ores with a silver base, known there under the name of Pacos. The same province presents also copper mines of considerable importance, from which are extracted native copper, orange oxide of copper, carbonate of copper (malachite), and copper pyrites, associated with some muriate of copper. In a few mines, masses of native copper of extraordinary magnitude have been found.

The second metalliferous region of the Andes occurs between the 21st and 15th degrees of south latitude. It includes the celebrated mountain of Potosi, situated in

nearly the 20th degree of south latitude, on the eastern slope of the chain, and several other districts likewise very rich, which extend principally towards the north-west, as far as the two banks of the lake Titicaca, and even beyond it, through a total length of nearly 150 leagues. All these districts, which formerly depended on Peru, were united in 1778, to the government of Buenos Ayres. The mines of Potosi were discovered in 1545, and have furnished since that period till our days, a body of silver which M. Humboldt values at 230,000,000*l.* sterling. The first years were the most productive. At that time ores were often found which afforded from 40 to 45 per cent. of silver. Since the beginning of the eighteenth century, the average richness of the ores does not exceed above from 3 to 4 parts in 10,000. These ores are therefore very poor at the present day; they have diminished in richness in proportion as the excavations have become deeper. But the total product of the mines has not diminished in the same proportion; abundance of ore having made up for its poverty. Hence, if the mountain of Potosi is not, as formerly, the richest deposit of ore in the world, it may, however, be still placed immediately after the famous vein of Guanaxuato. The ore lies in veins in a primitive clay state, which composes the principal mass of the mountain, and is covered by a bed of clay porphyry. This rock crowns the summit, giving it the form of a basaltic hill. The veins are very numerous; several, near their outcrop, were almost wholly composed of sulphuret of silver, antimoniated sulphuret of silver, and native silver. Others which offered near the surface merely sulphuret of tin, became richer as they descended. In 1790, seven copper mines were known in the vice-royalty of Buenos Ayres, seven of lead, and two of tin; the last being merely washings of sands found near the river Oraro.

On the opposite flank of the chain, in a low, desert plain, entirely destitute of water, which adjoins the harbour of Iquiqua, and forms a part of Peru, occur the silver mines of Huantajaya, celebrated for the immense masses of native silver, which have been sometimes found in them. In 1758, one was discovered weighing eight cwts.

M. Humboldt quotes 40 cantons of Peru as being at the present day most famous for their subterranean explorations of silver and gold. Those of gold are found in the provinces of Huailas and Patas; the silver is chiefly furnished by the districts of Huantajaya, Pasca, and Chota, which far surpass the others in the abundance of their ores.

The silver mines of the district of Pasco are situated about 30 or 40 leagues north of Lima, in $10\frac{1}{2}$ degrees of south latitude, 4400 yards above the sea-level, on the eastern slope of the Cordilleras, and near the sources of the river Amazons. They were discovered in 1630. These mines, and especially those of Cero de Yauricocha, are actually the richest in all Peru. The ore is an earthy mass of a red colour, containing much iron, mingled with particles of native silver, horn silver, &c., constituting what they call *Pacos*. At first nothing but these *pacos* was collected; and much gray copper and antimoniated sulphuret of silver were thrown among the rubbish. The mean product of all the ores is $\frac{1}{15}$; or an ounce and $\frac{2}{3}$ per cwt.; although some occur which yield 30 or 40 per cent. These rich deposits do not seem to be extended to a great depth; they have not been pursued farther than 130 yards, and in the greater part of the workings only to from 85 to 45. Forty years ago, these mines, which produced nearly 2,000,000 of piastres annually, were the worst worked in all South America. The soil seemed as if riddled with an immense number of pits, placed without any order. The drainage of the waters was effected by the manual labour of men, and was extremely expensive. In 1816, some Europeans, among whom were several miners from Cornwall, mounted several high-pressure steam engines, imported from England, which introduced a considerable improvement in the workings.

The mines of the province of Chota are situated in about seven degrees of south latitude. The principal ones are those of Gualcayoc, near Mecucampa, discovered in 1771; their outcrop occurs at the height of 4500 yards above the sea; the city of Mecucampa itself has 4000 yards of elevation, that is, higher than the highest summits of the Pyrenees. The climate is hence very cold and uncomfortable. The ore is a mixture of sulphuret of silver and antimoniated sulphuret, with native silver. It constitutes veins of which the upper portion is formed of *pacos*, and they sometimes traverse a limestone and sometimes a hornstone, which occurs in subordinate beds. The annual produce of the mines is 67,000 mares of silver, according to Humboldt.

In the districts of Huailas and Patas, which are at a little distance from the former two, gold mines are worked. This metal is extracted chiefly from the veins of quartz, which run across the primitive schistose mountains. The district of Huailas contains besides lead mines. Peru possesses, moreover, some mines of copper.

The quicksilver mine of Huancavelica, the only important mine of this species which has been worked in the New World, occurs on the eastern flank of the Andes of Peru, in 13 degrees of south latitude, at upwards of 6000 yards above the level of the sea. It does not seem referrible to the same class of deposits with the mines hitherto mentioned.

Indications of mercurial deposits have been observed in several other points of the Andes of Northern Peru, and of the south of New Granada.

Lastly, mines of sal-gem are known to exist in Peru, especially near the silver mines of Huantajaya.

On receding from the district of Chota, the Cordilleras are very indifferently stored with metallic wealth, to the isthmus of Panama, and even far beyond it. The kingdom of New Granada offers but a very small number of silver mines. There are some auriferous veins in the province of Antioquia, and in the mountains of Guamoco. The province of Caracas, the mountains of which may be considered as a ramification of the Cordilleras, presents at Aroa a copper mine which furnishes annually from 700 to 800 metric quintals (1400 to 1600 cwt.) of this metal. Finally, we may state in passing, that there is a very abundant salt mine at Zipaquira, in the province of Santa Fé, and that between this point and the province of Santa-Fé-de-Bogota, a stratum of coal occurs at the extraordinary height of 2700 yards.

Although Mexico presents a great variety of localities of ores, almost the only ones worked are those of silver. Nearly the whole of these mines are situated on the back or the flanks of the Cordilleras, especially to the west of the chain, nearly at the height of the great table land which traverses this region of the globe, or a little below its level in the chains which divide it. They lie in general between 2000 and 3000 yards above the sea; a very considerable elevation, which is favourable to their prosperity, because in this latitude there exists at that height a mean temperature mild, salubrious, and most propitious to agriculture. There were at the time of Humboldt's visit, from 4000 to 5000 deposits of ore exploited. The workings constituted 3000 distinct mines, which were distributed round 500 head quarters or *Reales*. These mines are not, however, uniformly spread over the whole extent of the Cordilleras. They may be considered as forming eight groups, which altogether do not include a greater space than 12,000 square leagues; viz. hardly more than the tenth part of the surface of Mexico.

These eight groups are, in proceeding from south to north,

1. The group of *Oaxaca*, situated in the province of this name at the southern extremity of Mexico properly so called, towards the 17th degree of north latitude. Besides silver mines, it contains the only veins of gold explored in Mexico. These veins traverse gneiss and mica-slate.

2. The group of *Tusco*. The most part of the mines which compose it are situated 20 or 25 leagues to the south west of Mexico, towards the western slope of the great plateau.

3. The group of *Biscania*, about 20 leagues north east of Mexico. It is of moderate extent, but it comprehends the rich workings of Pachuca, Real del Monte, and Moram. The district of Real del Monte contains only a single principal vein, named *Veta Bezi-cana* of Real del Monte, in which there are several workings; it is, however, reckoned among the richest of Mexico.

4. The group of *Zimapan*. It is very near the preceding, about 40 leagues north west of Mexico, towards the eastern slope of the plateau. Besides numerous silver mines, it includes abundant deposits of lead, and some mines of yellow sulphuret of arsenic.

5. The *Central group*, of which the principal point is *Guanarwato*, a city of 70,000 inhabitants, placed at its southern extremity, and 60 leagues N. N. W. of Mexico. It comprises among others the famous mine districts of *Guanarwato*, *Catorce*, *Zacatecas*, *Sombrerete*; the richest in Mexico, and which alone furnish more than half of all the silver which this kingdom brings into circulation.

The district of *Guanarwato* presents only one main vein, called the *Veta Madre*. This vein is enclosed principally in clay-slate, to whose beds it runs parallel, but occasionally it issues out of them to intersect more modern rocks. The vein is composed of quartz, carbonate of lime, fragments of clay slate, &c.; and includes the sulphurets of iron, of lead, and of zinc in great quantities, some native silver, sulphuret of silver, and red silver; its power (thickness of the vein) is from 43 to 48 yards. It is recognised and worked throughout a length of upwards of 13,000 yards; and contains 19 exploitations, which produced annually well on to 1,200,000*l.* in silver. One of the explorations, that of *Valenciana*, produces 320,000*l.*; being equal to about one-fifteenth of the total product of the 3000 mines of Mexico. Since 1764, the period of its discovery, its neat annual product has never been less than from two to three millions of francs (80,000*l.* to 120,000*l.*); and its proprietors, at first men of little fortune, became, in ten years, the richest individuals in Mexico, and perhaps in the whole globe.

The workings of this mine are very extensive, and penetrate to a depth of 550 yards. They employ a great many labourers.

The district of *Zacatecas* presents in like manner only a single vein in greywacke; which, however, is the seat of several workings.

The deposits mined at *Catorce* are in limestone; the mine called *Purissima de Catorce* has been explored to about 650 yards in depth; and yielded, in 1796, nearly 220,000*l.* There are also mines of antimony in the district of *Catorce*.

Towards the western part of the group of which we are now speaking, copper mines are worked in the provinces of Valladolid and Guadaluza; the ores being chiefly composed of protoxide of copper (orange copper), sulphuret of copper, and native copper. These mines produce about 2000 metric quintals of copper annually (440,000 lbs. English). In the same district, ores of tin are collected in the alluvial soils, particularly near Mount Gigante. The concretionary oxide of tin, so rare in Europe, is here the most common variety. This metal occurs also in veins.

The central part of Mexico contains many indications of sulphuret of mercury (cinabar); but in 1804 it was worked only in two places, and to an inconsiderable extent.

6. *The group of new Galicia* is situated in the province of this name, about 100 leagues N. W. from Mexico. It comprises the mines of Balanoe, one of the richest districts.

7. *The group of Durango and Sonora*, in the intendancies of the same name. It is very extensive. The mines are situated in part on the table land, and in part on the western slope. Durango is 140 leagues N. N. W. of Mexico.

8. *The group of Chinuahua*. It takes its name from the town of Chinuahua, situated 100 leagues N. of Durango. It is exceedingly extensive, but of little value; and terminates at 29° 10' of north latitude.

Mexico possesses, besides, several mines which are not included in the eight preceding groups. Thus the new kingdom of Leon, and the province of New Saint-Ander, present abundant mines of lead. New Mexico contains copper mines and many others.

Lastly, rock salt is mined in several points of New Spain; and coal seems to occur in New Mexico.

The richness of the different districts of the *silver mines* or *realces* is extremely unequal. Nineteen twentieths of these *realces* do not furnish altogether more than one-twelfth of the total product. This inequality is owing to the excessive richness of some deposits. The ores of Mexico are principally veins; beds and masses are rare. The veins traverse chiefly, and perhaps only primitive and transition rocks, among which certain porphyries are remarked as very rich in deposits of gold and silver. The silver ores are mostly sulphuret of silver, black antimoniated sulphuret of silver, muriate of silver (hornsilver), and gray copper. Many explorations are carried on in certain earthy ores, called *collorados*, similar to the *pacos* of Peru. Lastly, there are ores of other metals, which are worked principally, and sometimes exclusively, for the silver which they contain; such are the argentiferous sulphuret of lead, argentiferous sulphuret of copper, and argentiferous sulphuret of iron.

Ores of very great richness occur in Mexico; but the average is only from 3 to 4 ounces per cwt., or from 18 to 25 in 10,000. There are some, indeed, whose estimate does not exceed 2½ ounces. Almost all the argentiferous veins afford a little gold; the silver of Guanaxuato, for example, contains $\frac{1}{15}$. The enormous product of the Mexican mines is to be ascribed rather to the great facility of working them, and the abundance of ores, than to their intrinsic richness.

The art of mining was little advanced in this country at the period of Humboldt's journey; the workings presented a combination of small mines, each of which had only one aperture above, without any lateral communications between the different shafts.

The form of these explorations was too irregular to admit of their being called *workings by steps*. The shafts and the galleries were much too wide. The interior transport of the ores is generally effected on the back of men; rarely by mules. The machines for raising the ore and drawing off the water are in general ill combined; and the horse gigs for setting them in motion ill constructed. The timbering of the shafts is very imperfectly executed; the walled portions alone are well done. There are some galleries of drainage, but they are too few, and ill directed. Latterly, English capitalists and miners have formed companies for working the silver mines of Mexico; which will probably produce in time a happy revolution.

The silver ores of Spanish America are treated partly by fusion, and partly by amalgamation, but more frequently by the latter mode; hence the importation of mercury forms there an object of the highest importance, especially since the quicksilver mine of *Huancavelica* fell in, and ceased to be worked. This mine is the only one in Spanish America which belongs to the government. For the modern state of these mines, see SILVER.

The following table shews, according to M. de Humboldt, what was the annual product of the silver mines of South America, at the beginning of this century. It is founded in a great measure, upon official documents:—

| | | | |
|--------------|---|---|--|
| Mexico | - | - | 2,196,140 marcs, or 537,512 kil., worth £4,778,000 |
| Peru | - | - | 573,958 140,478 1,250,000 |
| Buenos-Ayres | - | - | 463,098 110,764 984,600 |
| Chili | - | - | 25,957 6,827 060,650 |
| Total | - | - | 3,259,153 795,581 7,073,280 |

To complete our picture of the mineral wealth of Spanish America, it remains to speak of its principal *gold mines*; but these belong to a geological locality, alluvial sands and gravel, very different from that of our present objects. The most important of these gold sands are washed on the western slope of the Cordilleras; viz. in New Granada, from the province of Barbaecos, to the isthmus of Panama, to Chili, and even to the shores of the seas of California. There are likewise some on the eastern slope of the Cordilleras, in the high valley of the river Amazonas. The washings of New Granada produce also some platina.

The mines, properly so called, and the washings of South America, furnish, altogether, 42,575 marcs, or 10,418 kilogrammes (22,920 lbs. Eng.) of gold, worth 1,435,720*l.*

MINES OF HUNGARY.

The metallic mines of this kingdom, including those of Transylvania, and the Bannat of Temeschwar, form four principal groups, which we shall denote by the group of the N. W., group of the N. E., group of the E., and group of the S. E.

The group of the N. W. embraces the districts of Schemnitz, Kremnitz, Koenigsberg, Neusohl, and the environs of Schmelnitz, Bethler, Rosenau, &c.

Schemnitz, a royal free city of mines, and the principal centre of the mines of Hungary, lies 25 leagues to the north of Buda, 560 yards above the sea, in the midst of a small group of mountains covered with forests. The most part of these mountains, the highest of which reaches an elevation of 1130 yards above the ocean, are formed of barren trachytes (rough trap rocks); but at their foot below the trachytic formation, a formation is observed consisting of green-stone porphyries, connected with syenites, passing into granite and gneiss, and including subordinate beds of mica-slate and limestone. It is in this formation that all the mines occur.

It has been long known that the greenstone porphyries of Schemnitz have intimate relations with the metalliferous porphyries of South America. M. Beudant, on comparing them with those brought by M. de Humboldt from Guanaxuato, Real del Monte, &c., has recognised an identity in the minutest details of colour, structure, composition, respective situation of the different varieties, and even in the empirical character of effervescence with acids. The metalliferous rocks appear at Schemnitz only in a space of small extent, comprehended partly in a small basin, of which the city occupies the south border. They are traversed by veins which, for the most part, cut across the stratification, but which also are sometimes obviously parallel to it. These veins are in general very powerful; their thickness amounting even to more than 40 yards, but their extent in length seems to be usually inconsiderable. They are numerous and parallel to each other. It appears that they have no side plates of vein stones (*sallebandes*), but that the metalliferous mass reposes immediately on the cheeks or sections of the rock, which is usually more or less altered, and includes always much pyrites near the point of contact, and even to a distance of several feet. The substances which constitute the body of these veins, are drusy quartz, carious quartz, ferriferous carbonate of lime, and sulphate of barytes, with which occur sulphuret of silver mixed with native silver containing more or less gold, which is rarely in visible scales; sulphuret of silver, argenteriferous galena, blende, copper and iron pyrites, &c. The sulphuret of silver and the galena are the two most important ores. Sometimes these two substances are insulated, sometimes they are mixed in different manners so as to furnish ores of every degree of richness, from such as yield 60 per cent. of silver down to the poorest galena. The gold seldom occurs alone; it generally accompanies the silver in a very variable proportion, which most usually approaches to that of 1 to 30.

The ores of Schemnitz are all treated by fusion; the poor galenas at the smelting house of Schemnitz (bleyhutte), and the resulting lead is sent as working lead to the smelting houses of Kremnitz, Neusohl, and Schernowitz, whither all the silver ores prepared in the different spots of the country are transported in order to be smelted.

The mines of Schemnitz, opened 800 years ago, have been worked to a depth of more than 350 yards. The explorations are in general well conducted. Excellent galleries of efflux have been excavated; the waters for impulsion are collected and applied with skill. It may be remarked, however, that these mines begin to decline from the state of prosperity in which they stood several years ago; a circumstance to be ascribed probably to the same pains being no longer bestowed on the instruction of the officers appointed to superintend them. Maria Theresa established in 1760, at Schemnitz, a school of mines. This acquired at its origin, throughout Europe, a great celebrity, which it has not been able to maintain.

Kremnitz lies about 5 leagues N. N. W. of Schemnitz, in a valley flanked on the right by a range of hills formed of rocks quite analogous to the metalliferous rocks of Schemnitz. In the midst of these rocks, veins are worked nearly similar to those of Schemnitz; but the quartz which forms their principal mass is more abundant, and contains more native gold. Here also are found sulphuret and hydrosulphuret of antimony,

which do not occur at Schemnitz. The metalliferous district is of very moderate extent, and is surrounded by the trachytic district which overlies it, forming to the East and West considerable mountains.

The city of Kremnitz is one of the most ancient free royal cities of mines in Hungary. It is said that mines were worked there even in the times of the Romans; but it is the Germans who, since the middle ages, have given a great development to these exploitations. There exists at Kremnitz a Mint-office, to which all the gold and silver of the mines of Hungary are carried in order to be parted, and where all the chemical processes, such as the fabrication of acids, &c., are carried on in the large way.

About 6 leagues N. N. E. from Schemnitz, on the banks of the Gran, lies the little village of *Neusohl*, founded by a colony of Saxon miners. The mountains surrounding it include mines very different from those of which we have been treating. At *Herrensgrand*, 2 leagues from Neusohl, greywacke forms pretty lofty mountains; this rock is covered by transition limestone, and is supported by mica-slate. The lower beds contain bands of copper ores, chiefly copper pyrites. The mica-slate includes likewise masses of ore, apparently constituting veins in it. These ores have been worked since the 13th century. The copper extracted contains in a hundred weight 6 ounces of silver.

Eighteen or twenty leagues to the east of *Neusohl*, we meet with a country very rich in iron and copper mines, situated chiefly in the neighbourhood of Bethler, Schmelnitz, Einsiedel, Rosenau, &c. Talcose and clay slates form the principal body of the mountains here, along with hornblende rocks. The ores occur most usually in strata. Those of iron, are sparry ore, and especially hydrate of iron, compact and in concretions, accompanied with specular iron ore. They give employment to a great many large smelting houses. The county of Gëmar alone contains 22 works; and that of Zips also a great number. The copper mines lie chiefly in the neighbourhood of Schmelnitz and Gëlnitz. The copper extracted contains about 6 or 7 ounces of silver in the hundred weight. Near *Zalathna* there is a quicksilver mine nearly inactive; and near *Rosenau* one of antimony.

To conclude our enumeration of the mineral wealth of this country, it remains merely to state that there are *opal* mines in the environs of *Czervenitz*, placed in the trachytic conglomerate.

GROUP OF THE NORTH EAST, OR OF NAGABANYA.

The mines of this group lie in a somewhat considerable chain of mountains, which, proceeding from the frontiers of Buchowina, where it is united to the Carpathians, finally disappears amidst the saliferous sandstones between the *Theiss*, *Lapos*, and *Nagy Szamos*, on the northern frontiers of Transylvania. These mountains are partly composed of rocks analogous to those of Schemnitz, traversed by veins which have much resemblance to the veins of this celebrated spot. Into these veins a great many mines have been opened, the most important of which are those of Nagabanya, Kapnick, Felsőhanya, Mészanya, Laposbanya, Olaposbanya, Ohlalapos. All these mines produce gold. Those of Laposbanya furnish, likewise, argentiferous galena; those of Olaposbanya contain copper and iron; and those of Kapnick copper. Realgar occurs in the mines of Felsőbanya; and orpiment in those of Ohlalapos. Several of them produce manganese and sulphuret of antimony. Lastly, towards the north, in the county of Marmarosch, lies the important iron mine of *Borscha*, and on the frontiers of Buchowina the lead mine of *Radna*, in which also much zinc ore occurs.

The mines composing the group of the East, or of *Abrudbanya*, occur almost all in the mountains which rise in the western part of Transylvania, between *Lapos* and *Maros*, in the environs of *Abrudbanya*. M. Beudant notices in this region, limestones, sandstones, trachytes, basalts, and sienite porphyries, apparently quite analogous to the greenstone porphyries of Schemnitz. It seems to be principally in the latter rocks that the mines forming the wealth of this country occur; but some of them exist also in the mica-slate, the greywacke, and even in the limestone. The principal mines are at Nagyag, Korosbanya, Vorospatak, Boitza, Csertesch, Fatzbay, Almas, Porkura, Butschum, and Stonischa. There are, in all, 40 exploitations; the whole of which produce auriferous ores smelted at the foundry of *Zalathna*. These mines contain also copper, antimony, and manganese. They are celebrated for their *tellurium* ore, which was peculiar to them prior to the discovery of this metal a few years back in Norway. The auriferous deposits contained in the greenstone porphyry are often very irregular. The mines of Nagyag are the richest and best worked. The numerous veins occur partly in the sienite porphyry, and partly in the greywacke. The auriferous ore is accompanied with galena, realgar, manganese, iron, and zinc. There are iron mines in great beds near *Vayda-Huniad* and *Gyalar*. Some cobalt mines are also noticed.

The group of the S. E., or of the *Bannat of Temeschwar*, occurs in the mountains which block up the valley of the Danube at *Orschova*, through a narrow gorge of which the river escapes. The principal mines are at *Oravitza*, *Moldawa*, *Szaska*, and *Dognaaczka*.

They produce chiefly argentiferous copper, yielding a marc of silver (nearly $\frac{1}{4}$ pound) in the hundred weight, with occasionally a little gold. Ores of lead, zinc, and iron, are also met with. The mines are famous for their beautiful specimens of blue carbonate of copper, and various other minerals. The mine of Moldawa affords likewise orpiment. These metallic deposits lie in beds and veins; the former occurring particularly between the mica-slate and the limestone, or sometimes between the limestone and the sienite porphyry. Well defined veins also are known to exist in the sienite and the mica-slate. The Bannat possesses moreover important iron-mines at Dombrawa and Ruchersberg; near Dombrawa sulphuret of mercury is found. Cobalt mines occur likewise in these regions.

The mines constituting the four groups now described are not the sole metallic mines possessed by Hungary. A few others, but generally of little importance, are scattered over different parts of this kingdom. Several have been noticed in the portion of the Carpathians which separates Transylvania from Moldavia and Wallachia. Their principal object is the exploration of some singular deposits of galena.

Besides the mines just noticed, Hungary contains some coal mines, numerous mines of rock-salt, and several deposits of golden sands situated chiefly on the banks of the Danube, the Marosch, and the Nera.

The mines of the kingdom of Hungary produce annually, according to M. Heron de Villefosse, 5218 marcs, or 2810 pounds English of gold, worth 175,976*l.*; and about 85,000 marcs, or 45,767 pounds of silver, worth 186,132*l.* The mines of Transylvania furnish nearly the half of the whole quantity of gold, and one seventeenth of the silver now stated. The other mines of Europe produce together nearly twice as much silver, but merely a few marcs of gold. Hungary affords besides from 18 to 20 thousand metric quintals (about 4,000,000 *liba.* Eng.) of copper annually, and a great deal of iron.

From these mines proceed likewise from 3000 to 4000 metric quintals (660,000 to 880,000 *liba.* E.) of lead; a quantity not more than is needed by the refining-houses for the ores of silver and gold.

MINES OF THE ALTAIAN MOUNTAINS.

At the western extremity of the chain of the Altayan mountains, which separate Siberia from Chinese Tartary, there exists a number of metalliferous veins, in which several important workings have been established since the year 1742. They constitute the locality of the mines of Kolywan; the richest in the precious metals of the three districts of this kind existing in Siberia.

These mines are opened up in the schistose formations which surround to the N. and W. and to the S. W. the western declivity of the high granitic chain, from which they are separated by formations consisting of other primitive rocks. These schists alternate in some points with quartzose rocks, called by M. Renovants hornstone, and with limestone. They are covered by a limestone, replete with aramonites. The metalliferous region forms a semicircle, of which the first lofty mountains occupy the centre.

The most important exploration of this country is the silver mine of Zmëof, or Zmeinogarsk, in German Schlangenberg, situated to the N. W. of the high mountains in 51° 9' 25" N. L. and 79° 49' 50" long. east of Paris. It is opened on a great vein, which contains argentiferous native gold, auriferous native silver, sulphuret of silver, hornsilver, gray copper, sulphuret of copper, green and blue carbonated copper, red oxide of copper, copper pyrites, sulphuret of lead, and great masses of testaceous arsenic slightly argentiferous. There occur likewise sulphuret of zinc, iron pyrites, and sometimes arsenical pyrites. The gangues (vein stones) of these different ores are sulphate of baryta, carbonate of lime, quartz, but rarely fluete of lime. The principal vein, which is of great power, has been traced through a length of several hundred fathoms, and to a depth of no less than 96 fathoms. In its superior portion, it has an inclination of about 50 degrees; but lower down it becomes nearly vertical. Its roof is always formed of clay-slate. On the floor of the vein, the slate alternates with hornstone. This vein pushes out branches in several directions; it is intersected by barren veins, and presents successive stages of different richness. The first years were the most productive. The German miners employed subsequently by the Russian government have introduced regularity into the workings; and have excavated a gallery of efflux 585 fathoms long.

The most important of the other silver mines of this department are those of Tcherapanofski, 3 leagues S. E. of Zmëof; those of Smenofski, 10 leagues S. E.; those of Nicolaiski, 20 leagues to the S. S. W.; and of Philipofski, 90 leagues S. E. of the same place. The last mine lies on the extreme frontier of Chinese Tartary. It is not known whether the southern slope of the Altaic chain within the Chinese territories, contains metalliferous deposits.

The ores extracted from these different mines yield on an average per quintal an

ounce of silver, which contains 3 per cent. of gold. Their annual product was towards 1786, according to M. Patrin, 3000 marcs, or 1615 liba. avoirdupois of gold, worth 101,151*l.*; and 60,000 marcs, or 31,020 liba. avoird. of silver, worth 130,520*l.*

The precious metals are not the sole product of this mineral district. There is an important copper-mine 15 leagues N. W. of Zméof, in a chain of hills formed of granitic rocks, schists, porphyries, and shell-limestone, graduating into the plain. The vein presents copper pyrites, sulphuret of copper, and native copper, disseminated in argillaceous substances, more or less ferruginous, and of different degrees of hardness. This mine, which bears the name of Aleiski-Loktefski, furnished annually at the date of 1782, 1500 quintals (metric), or 330,000 liba. avoird. of copper, which was coined into money in the country itself.

At Tchakirskoy, on the banks of the Tcharisch, towards the northern extremity of the metalliferous semicircle, mentioned above, there is a mine of argentiferous copper and lead, opened in a very large but extremely short vein. Besides the lead and copper ores, including a little silver, this mine affords a great quantity of calamine (carbonate of zinc), which forms occasionally fine stalactites of a white or green colour.

The northern flank of the Altaï mountains presents few mines. Some veins of copper exist 2000 leagues east of Zméof, near the spot where the river Janissei issues from the Saianean mountains, which are a prolongation of the Altayan chain.

There is no lead-mine, properly so called, in the Altaï mountains. Almost all the lead which is required for the treatment of the silver and gold ores is obtained from the department of Nertchinsk, situated 700 leagues off, on the borders of the river *Amour*.

The first smelting-house erected in this district in the middle of the metalliferous region at *Kolywan*, the place from which it takes its name. It has been suppressed on account of the dearth of wood in the neighbourhood of the mines. The principal existing foundry is that of Bornaul on the Ob, 50 leagues north of Zméof.

MINES OF THE URAL MOUNTAINS.

This chain of mountains, which begins on the coasts of the icy sea, and terminates in the 50th degree of latitude amidst the steppes of the *Kerguis*, after having formed, through an extent of more than 40 leagues, the natural limit between Europe and Asia, contains very rich and very remarkable deposits of metallic ores, which have given rise to important mines of iron, copper, and gold. These explorations are situated on the two slopes, but chiefly on the one that looks to Asia, from the environs of Ekaterinbourg to about 120 or 130 leagues north of that city. They constitute the department of the mines of Ekaterinbourg, one of the three belonging to Siberia.

The copper-mines are pretty numerous, and lie almost wholly on the oriental slope of the chain. They are opened into veins of a very peculiar nature, and which although very powerful at the surface, do not extend to any considerable depth. These veins are in general filled with argillaceous matters, penetrated with red oxide of copper, and mingled with green and blue carbonated copper, sulphuret of copper, and native copper. The most important workings are those of *Tourinski* and *Goumechafski*.

The first are situated 120 leagues north of Ekaterinbourg, towards the 60th degree of N. latitude, at the eastern base of the Uralian mountains, near the banks of the *Touria*. They amount to three, opened in the same vein, which turns round an angle presented by the chain in this place. The ground is composed of a porphyry with a hornstone basis, of clay-slate, and of a white or grayish limestone, which form the roof and floor of the vein. The ore yields from 18 to 20 per cent., and these mines produced annually in 1786, 10,000 metric quintals (2,200,000 liba avoird.) of copper.

The mine of Goumechefski lies 12 or 15 leagues S. W. of Ekaterinbourg, near a lake bordered by primitive mountains, which form in this region the axis of the chain of the Urals. This mine is celebrated for the beautiful malachites that occur in it. It has furnished almost all the fine specimens of this substance employed in jewellery. The vein, of which the sides are calcareous, is vertical, and runs north and south. It does not sink deeper than about 50 yards, and is filled with a species of coarse pudding-stone, composed of masses of primitive rocks. The ore yields from 3 to 4 per cent. of copper, and the mine furnished about the year 1786, 4,400,000 liba. avoird. of this metal *per annum*.

The beds of iron ore occur generally at a certain distance from the axis of the central chain. Those of the western slope lie sometimes in a gray compact limestone, which contains *astrochi* and other petrifications, and whose geological age has not been ascertained, but it appears to be much more modern than the rocks of the central chain. Both the one and the other seem to form large veins, which extend little in depth, or rather fill irregular and shallow cavities. The most common ore is the hydrate of iron (bog ore), hematite, or compact iron ore, sometimes mixed or accompanied with hydrate of manganese, and occasionally with ores of zinc, copper, and lead. Black oxide of iron, possessing magnetic polarity, likewise frequently occurs, particularly in the

mines of the eastern slope, on which, in fact, entire mountains of loadstone repose. All these ores, mixed with a greater or less quantity of clay differently coloured, are worked by open quarries, and most usually without using gunpowder, or even iron wedges. They yield rarely less than 50 or 60 per cent., and keep in action numerous smelting-houses situated on the two flanks of the chain; the oldest of them have been established since 1628, but the greater number date only from the middle of the 18th century. The most celebrated mines are those of *Balgodat* and *Keakanar*, situated on the eastern slope from 30 to 50 leagues north of *Ekaterinbourg*. In the foundries of the eastern slope, anchors, cannons, bullets, &c. are fabricated; and in the whole a considerable quantity of bar iron. The products of the works on the western side are directly embarked on the different feeders of the Volga, from which they are at no great distance. Those of the eastern slope are transported during winter on sledges to the same feeder streams, after crossing the least elevated passages of the Urals.

The quantity of materials fabricated by the iron works of both slopes, amounted annually, towards the year 1790, to more than 11,000,000 lbs. avoird. This country is peculiarly favoured by nature for this species of industry; for vast deposits of excellent iron ores occur surrounded by immense forests of firs, pines, and birches; woods, whose charcoal is excellently adapted to the fabrication of iron.

The copper-mines of the Uralian mountains, and the greater part of the iron mines and foundries, form a portion of the properties of some individuals, who may be instanced as among the richest in Europe. The Russian government has neglected no opportunity of promoting these enterprizes. It has established at *Tourinsky* a considerable colony, and at *Irbits* a fair which has become celebrated.

There is only one gold mine in the Ural mountains, that of *Beresof*, situated three leagues N. E. of *Ekaterinbourg*, at the foot of the Urals, on the Asiatic side. It is famous for the chromate of lead, or red lead ore, discovered there in 1776, and worked in the following years, as also for some rare varieties of minerals. The ore of *Beresof* is a cavernous hydrate of iron (bog ore), presenting here and there some small striated cubes of hepatic iron, and occasionally some pyrites. It contains 5 parts of native gold in 100,000. This deposit appears to have a great analogy with the deposits of iron ore of the same region. It constitutes a large vein, running from N. to S., encased in a formation of gneiss, hornblende schists, and serpentine, and which does not appear to dip to any considerable depth. It becomes poor in proportion to its distance from the surface. The exploitation, which is in the open air, has dug down 25 yards; having been carried on since the year 1726. The gold is extracted from the ore by stamping and washing. In 1786, 500 marcs were collected; but the preceding years had furnished only 200, because they then worked further from the surface. German miners were called in to direct the operations. On some points of the Ural mountains, and the neighbouring countries, deposits of an auriferous clay have been noticed; but they have not hitherto been worked.

Beds of chromate of iron have also been discovered in these mountains.

The beautiful plates of mica, well known in mineral cabinets, and even in commerce, under the name of *Muscovy talc*, or *Russian mica*, come from the Urals. There are explorations for them near the lake *Tschebarkoul*, on the eastern flank of this chain. From the same canton there is exported a very white clay, apparently a *kaolin*.

25 leagues north of *Ekaterinbourg*, near the town of *Mourzinsk*, there occur in a graphic granite, numerous veins, containing *amethysts*, several varieties of *beryl*, *emeralds*, *topazes*, &c.

Table of the production of the Russian Mines during the years 1830, 1831, 1832, 1833, and 1834; by M. Teploff, one of their Officers.

| Substances. | 1830. | 1831. | 1832. | 1833. | 1834. |
|-------------------|-------------|-------------|-------------|-------------|-------------|
| | <i>ktl.</i> | <i>ktl.</i> | <i>ktl.</i> | <i>ktl.</i> | <i>ktl.</i> |
| Gold - - | 6,260 | 6,582 | 6,916 | 6,706 | 6,626 |
| Platinum - - | 1,742 | 1,767 | 1,907 | 1,919 | 1,695 |
| Auriferous silver | 20,974 | 21,563 | 21,454 | 20,552 | 20,666 |
| | | | | (3) | |
| Copper - - | 8,860,696 | 3,904,533 | 3,620,201 | 3,387,252 | ? |
| Lead - - | 698,478 | 792,935 | 688,351 | 716,500 | ? |
| | | | | (3) | |
| Cast iron - - | 182,721,274 | 180,043,730 | 162,480,224 | 159,118,372 | ? |
| | | (2) | | | |
| Salt - - | 342,240,893 | 282,821,358 | 372,776,283 | 491,862,299 | ? |
| Coal - - | 7,863,642 | 9,774,998 | 6,596,034 | 8,227,528 | ? |
| Naphtha - - | 4,253,000 | 4,253,000 | 4,253,000 | 4,253,000 | ? |

MINES OF THE VOSGES AND THE BLACK FOREST.

These mountains contain several centres of exploration of argentiferous ores of lead and copper, iron ores, and some mines of manganese and anthracite.

At the *Croix-aux-mines*, department of the Vosges, a vein of argentiferous lead has been worked, which next to the veins of Spanish America, is one of the greatest known. It is several fathoms thick, and has been traced and mined through an extent of more than a league. It is partly filled with debris, among which occurs some argentiferous galena. It contains also phosphate of lead, antimoniated sulphuret of silver, &c. It runs from N. to S. nearly parallel to the line of junction of the gneiss, and a porphyroid granite, that passes into sienite and porphyry. In several points it cuts across the gneiss; but it probably occurs also between the two rocks. It has never been worked below the level of the adjoining valley. The mines opened on this vein produced, it is said, at the end of the 16th century, 26,000*l.* per annum; they were still very productive in the middle of the last century, and furnished, in 1756, 2,640,000 *lbs.* avoird. of lead, and 6000 marcs, or 3230 pounds avoird. of silver.

The veins explored at *Sainte Marie of the mines*, also traverse the gneiss; but their direction is nearly perpendicular to that of the vein of the *Croix*, from which they are separated by a barren mountain of sienite. They contain besides galena, several ores of copper, cobalt, and arsenic; all more or less argentiferous. There is found also at a little distance from *Saint Mary of the mines*, a vein of sulphuret of antimony. The mines of *Sainte Marie*, opened several centuries ago, are among the most antient in France; and yet they have been worked only down to the level of the adjoining valleys.

There has been opened up in the environs of *Girromagny*, on the southern verge of the Vosges, a great number of veins, containing principally argentiferous ores of lead and copper. They run nearly from N. to S., and traverse porphyries and clay-slates; a system which has some analogy with the metalliferous district of Schemnitz. The workings have been pushed so far as 440 yards below the surface. These mines were in a flourishing state in the 14th and 16th centuries; and became so once more at the beginning of the 17th, when they were undertaken by the house of Mazarin. In 1743 they still produced 100 marcs, fully 52 *lbs.* avoird. of silver in the month.

The mines of *la Croix*, of *Sainte-Marie-aux-mines*, and of *Girromagny*, are now abandoned; but it is hoped that those of the first two localities will be resumed ere long.

In the mountains of the Black Forest, separated from the Vosges by the valley of the Rhine, but composed of the same rocks, there occur at *Badenweiler* and near *Hochberg*, not far from Freyburg, workings of lead in great activity. These form six distinct mines, and annually afford 88,000 *lbs.* avoird. of lead, and 200 marcs of silver. In the *Furstenberg* near *Wolfach*, particularly at *Wittichen*, there are mines of copper, cobalt, and silver. The mines of *Wittichen* produced, some years ago, 1600 marcs, or near 880 *lbs.* avoird. of silver *per annum*. They supply a manufactory of smalt, and one of arsenical products. A few other inconsiderable mines of the same kind exist in the grand duchy of Baden, and in the kingdom of Wurtemberg.

Several important iron mines are explored in the Vosges; the principal are those of *Framont*, in the department of the Vosges, whose ores are red oxide of iron and brown hematite, which appear to form veins of great thickness, much ramified, and very irregular, in a district composed of greenstone, limestone and greywacke. The subterranean workings, opened on these deposits, have been hitherto very irregular. There has been discovered lately in these mines, an extremely rich vein of sulphuret of copper. At *Rothau*, a little to the east of *Framont*, thin veins of red oxide of iron are worked; sometimes magnetic, owing probably to an admixture of protoxide of iron. These veins run through a granite, that passes into sienite. At *Saulnot* near *Belfort*, there are iron mines, analogous to those of *Framont*.

In the neighbourhood of *Ihann* and *Massovaux*, near the sources of the Moselle, veins are worked of an iron ore, that traverse formations of greywacke, clay-slate, and porphyry. Lastly, in the north of the Vosges, near *Bergzabern*, *Erlenbach*, and *Schenau*, several mines have been opened on very powerful veins of brown hematite and compact bog ore, accompanied with a little calamine, and a great deal of sand and debris. In some points of these veins, the iron ore is replaced by various ores of lead, the most abundant being the phosphate, which are explored at *Erlenbach* and *Katzenthal*. These veins traverse the sandstone of the Vosges, a formation whose geological position is not altogether well known, but which contains iron mines analogous to the preceding at *Langenthal*, at the foot of Mount *Tonnerre*, and in the *Palatinate*. Many analogies seem to approximate to the sandstone of the Vosges, the sandstone of the environs of *Saint Avold* (Moselle), which includes the mine of brown hematite of *Crentswald*, and the lead mine of *Bleyberg*, analogous to the lead mine of *Bleyberg*, near *Aix-la-Chapelle*.

At *Cruttnich* and *Tholey*, to the north of the *Sarrebruck*, mines of manganese are worked, famous for the good quality of their products. The deposit exploited at *Cruttnich*, seems to be inclosed in the sandstone of the *Vosges*, and to constitute a vein in it, analogous to the iron veins mentioned above.

There has been recently opened a manganese mine at *Lavelline* near *La Creix-aux-mines*, in a district of gneiss with porphyry.

In the *Vosges* and the *Black Forest* there are several deposits of anthracite (stone-coal), of which two are actually worked, the one at *Zunswir* near *Offenbourg*, in the territory of *Baden*, and the other at *Uvoltz*, near *Cernay*, in the department of the *Upper Rhine*. There are also several deposits of the true coal formation on the flanks of the *Vosges*.

MINES OF THE HARTZ.

The name *Hartz* is given generally to the country of *Forests*, which extends a great many miles round the *Brocken*, a mountain situated about 55 miles W. S. W. of *Magdeburg*, and which rises above all the mountains of North Germany, being at its summit 1226 yards above the level of the sea. The *Hartz* is about 43 miles in length from S. S. E. to N. N. W., 18 miles in breadth, and contains about 450 square miles of surface. It is generally hilly, and covered two-thirds over with forests of oaks, beeches, and firs. This rugged and picturesque district corresponds to a portion of the *Silva Hercynia* of *Tacitus*. As agriculture furnishes few resources there, the exploration of mines is almost the only means of subsistence to its inhabitants, who amount to about 50,000. The principal cities, *Andreasberg*, *Clausthal*, *Zellerfeld*, *Altenau*, *Lautenthal*, *Wildemann*, *Grund*, and *Goslar*, bear the title of mine-cities, and enjoy peculiar privileges; the people deriving their subsistence from working in the mines of lead, silver, and copper, over which their houses are built.

The most common rock in the *Hartz* is greywacke. It encloses the principal veins, and is covered by a transition limestone. The granite of which the *Brocken* is formed supports all this system of rocks, forming as it were, their nucleus. Trap and hornstone rocks appear in certain points.

The veins of lead, silver, and copper, which constitute the principal wealth of the *Hartz*, do not pervade its whole extent. They occur chiefly near the towns of *Andreasberg*, *Clausthal*, *Zellerfeld*, and *Lautenthal*; are generally directed from N. W. to S. E., and dip to the S. W., at an angle of 80° with the horizon.

The richest silver mines are those of the environs of *Andreasberg*, among which may be distinguished the *Samson* and *Neufang* mines, worked to a depth of 560 yards. In the first of them, there is the greatest *step* exploitation to be met with in any mine. It is composed of 80 *direct steps*, and is more than 650 yards long. These mines were discovered in 1520, and the city was built in 1521. They produce argentiferous galena, with silver ores properly so called, such as red silver ore, and ore of cobalt.

The district which yields most argentiferous lead, is that of *Clausthal*. It comprehends a great many mines, several of which are worked to a depth of 550 yards. Such of the mines as are at the present day most productive, have been explored since the first years of the 18th century. The two most remarkable ones are the mines of *Dorothy*, and the mine of *Caroline*, which alone furnish a large proportion of the whole neat product. The grant of the *Dorothy* mine extends over a length of 257 yards, in the direction of the vein, and through a breadth of nearly 22 yards perpendicularly to that direction. Out of these bounds, apparently so small, but which however surpass those of the greater part of the *concessions* in the *Hartz*, there was extracted from 1709 to 1807 inclusively, 883,722 mares of silver, 768,845 quintals of lead, and 2385 quintals of copper. This mine and that of *Caroline* have brought to their shareholders in the same period of time, more than 1,120,000*l.*; and have besides powerfully contributed by loans without interest to carry on the exploration of the less productive mines. It was in order to effect the drainage of the mines of the district of *Clausthal*, and those of the district of *Zellerfeld* adjoining, that the great gallery of efflux was excavated.

Next to the two districts of *Clausthal* and *Zellerfeld*, and *Andreasberg*, comes that of *Goslar*, the most important working in which is the copper mine of *Rammelsberg*, opened since the year 968, on a mass of copper pyrites, disseminated through quartz, and mingled with galena and blende. It is worked by shafts and galleries, with the employment of fire to break down the ore. This mine produces annually from 1200 to 1300 metric quintals (about 275,000 *liba. avoird.*) of copper. The galena extracted from it yields a small quantity of silver, and a very little gold. The latter metal amounts to only the five millionth part of the mass explored; and yet means are found to separate it with advantage. The mine of *Lautenberg* is worked solely for the copper, and it furnishes annually near 66,000 *liba. avoird.* of that metal.

Besides the explorations just noticed, there are a great many mines of iron in different parts of the *Hartz*, which give activity to important forges, including 21 smelting

cupolas. The principal ores are sparry iron, and red and brown hematites, which occur in veins, beds, and masses. Earthy and alluvial ores are also collected.

The territory of Anhalt-Bernbourg presents, towards the S. E. extremity of the Hartz, lead and silver mines, which resemble closely those of the general district. They produce annually 33,000 lbs. avoird. of lead.

At the southern foot of the Hartz, at Ilfeld, there is a mine of manganese.

The exploration of the Hartz mines may be traced back for about 900 years. The epoch of their greatest prosperity was the middle of the 18th century. Their gross annual amount was in 1808, upwards of one million sterling. Lead is their principal product, of which they furnish annually 6,600,000 lbs. avoird., with 36,000 mares, or 18,700 lbs. avoird. of silver, about 360,000 lbs. avoird. of copper, and a very great quantity of iron. They are celebrated for the excellence of the mining operations; and the activity, patience, and skill of their workmen.

The Hartz is referred to especially for the manner in which the waters are collected, and economised for floating down the timber, and impelling the machinery. With this view, dams or lakes, canals and aqueducts, have been constructed, remarkable for their good execution. The water-courses are formed either in the open air round the mountain sides, or through their interior as subterranean galleries. The open channels collect the rain waters, as well as those proceeding from the melting of snows, from the springs and streamlets, or small rivers that fall in their way. The subterranean conduits are in general the continuation of the preceding, whose circuits they cut short. These water-courses present a development in whole, of 125 miles. The banks of some of the reservoirs are of an extraordinary height. In the single district of Clausthal there are 34 tanks, which supply water to 92 wheels of nearly 30 feet diameter. 55 of these serve for the drainage of water; and 37 for the extraction of ores.

MINES OF THE EAST OF GERMANY.

We shall embrace under this head the mines opened in the primitive and transition territories, which constitute the body of a great portion of Bohemia, and the adjacent parts of Saxony, Bavaria, Austria, Moravia, and Silesia.

Among the several chains of small mountains that cross these countries, the richest in deposits of ore is the one known under the name of the *Erzgebirge*, which separates Saxony from Bohemia on the left bank of the Elbe.

The *Erzgebirge* contains a great many mines whose principal products are *silver*, *tin*, and *cobalt*. These mines, whose exploration remounts to the 12th century, and particularly those situated on the northern slope within the kingdom of Saxony, have been long celebrated. The school of mines established at Freyberg, was at one time considered as the first in the world. This is a small city near the most important workings, 8 leagues W. S. W. of Dresden, towards the middle of the northern slope of the *Erzgebirge*, 440 yards above the level of the sea, in an agricultural and trading district, well cleared of wood. These circumstances have modified the working of the mines; and render it difficult to draw an exact parallel between them, and those of the Hartz, which are their rivals in good exploration. They are peculiarly remarkable for the perfection with which the engines are executed both for drainage and extraction of ores, all moved by water or horses; for the regularity of almost all the subterranean labours; and for the beauty of their *walling* masonry. In the portion of these mountains belonging to Saxony, the underground workings employ directly from 9000 to 10,000 men, who labour in more than 400 distinct mines, all associated under the same plan of administration.

The *silver* mines of the *Erzgebirge* are opened on veins which traverse gneiss, and though quite different in this respect from the argentiferous veins of *Guanaaruto*, *Schemnitz*, and *Zneof*, present but a moderate thickness, never exceeding a few feet. They form several groups, whose relative importance has varied very much.

For a long time back, those of the environs of Freyberg are much the most productive; and their prosperity has been always on the advance, notwithstanding the increasing depth of the excavations. The deepest of the whole is that of Kuschacht, which penetrates to 450 yards beneath the surface, that is nearly down to the sea-level. The most productive and the most celebrated is the mine of Himmelsfürst; that of Beschertgluck is also very rich.

Among the explorations of the *Erzgebirge*, there are none which were formerly so flourishing as those of Marienberg, a small town situated seven leagues S. S. W. of Freyberg. In the 16th century, ores were frequently found there, even at a short distance from the surface, which yielded 85 per cent. of silver. The disasters of the thirty years' war put a term to their prosperity. Since that period they have continually languished; and their product now is nearly null.

Our limits do not permit us to describe in detail the silver mines that occur near

Ehrenfriedersdorf, Johanna-Georgenstadt, Annaberg, Oberweisenthal, and Schneeberg. Those of the last three localities produce also cobalt.

The mines of Saint-Georges, near Schneeberg, opened in the 15th century as iron mines, became celebrated some time after as mines of silver. Towards the end of the 15th century, a mass of ore was found there which afforded 400 quintals of silver. On that lump, Duke Albert kept table at the bottom of the mine. Their richness in silver has diminished since then; but they have increased more in importance during the last two hundred years, as mines of cobalt, than they had ever been as silver mines. Saxony is the country where cobalt is mined and extracted in the most extensive manner. It is obtained from the same veins with the silver. Smalt, or cobalt-blue, is the principal substance manufactured from it. The lead and the copper are in this country only accessory products of the silver mines, from which 120,000 lbs. avoird. of the first of these metals are extracted, which are hardly sufficient for the metallurgic operations; and from 50,000 to 60,000 lbs. of copper. A little bismuth is extracted from the mines of Schneeberg and Freyberg. Some manganese is found in the silver mines of the Erzgebirge, and particularly at Johann-Georgenstadt.

The mines of Saxony produce a little argentiferous galena, and argentiferous gray copper; the minerals with a base of native silver are the principal ores. They are treated in a great measure by amalgamation. All those of Freyberg are carried to the excellent smelting house of Halsbrück, situated on the Malde, near that city. The average richness of the silver ores throughout Saxony is only from 3 to 4 oz. per quintal; viz. nearly equal to that of the ores of Mexico, and very superior to the actual richness of the ores of Potosi. The silver extracted from them contains a little gold. The Saxon mines produce annually 52,000 marcs of silver. Of these, the district of Freyberg alone furnishes 46,000; and among the numerous mines of that district, that of Himmelsfurst of itself produces 10,000 marcs.

Silver mines exist also on the southern declivity of the Erzgebirge, which belongs to Bohemia, at *Joachimsthal* and *Bleystadt*, to the N. E. of Eger. Argentiferous galena is chiefly extracted from these. The mines of Joachimsthal have been explored to a depth of 650 yards. They were formerly very flourishing; but in 1805 they were threatened with an impending abandonment. The ancient mines of Kuttenberg, situated in the same region, have been excavated, according to Agricola, to upwards of 1000 yards from the surface soil.

The southern slope of the Erzgebirge possesses cobalt mines like the northern slope; but they are of much less importance. Some occur, particularly in the neighbourhood of Joachimsthal. Lastly, on the same slope, slightly productive copper mines are mentioned at Gröslitz, near Joachimsthal; at Catharineberg, eight leagues N. of Saatz; and at Kupferberg, lying between the two. At Gröslitz, the ore is a cupreous pyrites, accompanied by blende. The ores of Catharineberg are argentiferous.

Next to the silver mines, the most important explorations of the Erzgebirge are those of tin. This metal occurs in veins, massive, and disseminated in masses of hyaline gray quartz, imbedded in the granite. It is also found in alluvial sands. The most important tin mine of the Erzgebirge is that of Altenberg, in Saxony, which has been under working since the 15th century. Some tin is mined also near Gayer, Ehrenfriedersdorf, Johann-Georgenstadt, Scheibenberg, Annaberg, Seiffen, and Marienberg, in Saxony. At Zinnwald it is also found; where the stanniferous district belongs partly to Saxony, and partly to Bohemia; as also important mines occur in the latter territory at Schlackenwald and Abertham, and slightly productive ones at Platten and Joachimsthal. In several of these mines, particularly at Altenberg and Gayer, fire is employed for attacking the ore, because it is extremely hard. In almost the whole of them, chambers of too great dimensions have been excavated, whence have arisen, at different epochs, vexatious sinkings of the ground. One of these may still be seen at Altenberg, which is 130 yards deep, and nearly 50 in breadth. The mines of Abertham are explored to a depth of 550 yards; and those of Altenberg to 330. The tin mines of the Erzgebirge produce annually 484,000 lbs. avoird. of this metal.

The tin ores are accompanied by arsenical pyrites, which, in the roasting that it undergoes, produces a certain quantity of arsenious acid.

The Erzgebirge presents also a great many iron mines, particularly in Saxony, at *Rodenberg*, near Cradorf, in the county of Henneberg, where the workings penetrate to a depth of 220 yards, and in Bohemia, at *Platten*, where may be remarked especially the great explorations opened on the vein of the *Irrgang*.

There is also in the Erzgebirge a mine of anthracite (stone coal) at *Schenfeld*, near Frauenstein in Saxony.

The ancient rock formations which appear in the remainder of Bohemia, and in the adjacent portions of Bavaria, Austria, Moravia, and Silesia, are much less rich in metals than the Erzgebirge. No explorations of much importance exist there.

The *Fichtelgebirge*, a group of mountains standing at the western extremity of the

Erzgebirge, between Hoff and Bayreuth, contains some mines, among which may be noticed, principally, mines of magnetic black oxide of iron.

Argentiferous lead mines have been mentioned at *Miess*, 25 leagues W. S. W. of Prague, at the N. E. base of the western part of *Bomerwaldgebirge*, a chain of mountains which separates Bohemia from Bavaria. There are some also at *Frasibrom*, 12 leagues S. W. of Prague, at the extremity of the mountains which separate Behrun from Moldau. In the latter, the argentiferous galena is accompanied by blende, in which the presence of cadmium has been observed. These mines, and those of Joachimsthal and of Bleystadt, furnish annually at present 220,000 pounds avoird. of lead, and from 2000 to 3000 marks of silver. The circle of Behrun, to the S. W. of Prague, contains some inconsiderable mines of mercury. The eastern part of the *Bomerwaldgebirge*, which separates Bohemia from Austria and Moravia, presents some mines on its S. E. slope. Those of the environs of *Iglau*, in Moravia, and some others situated in Austria, produce annually from 4000 to 5000 marks of silver. The mines of these two countries yield also copper, and in several the copper ores are argentiferous. Moravia comprehends several iron works, which are in part supplied by magnetic iron ores analogous to those of Sweden.

The N. E. slope of the *Riesengebirge* (giant mountains), which separate Bohemia from Silesia, presents also several explorations. The argentiferous copper mines of *Rudolstadt* and of *Kupferberg*, have been stated as producing annually a considerable quantity of copper, and from 600 to 700 mares of silver; as also the cobalt mine of *Maris-anna Querback*, the whole in the circle of *Qauer*; and the mines of arsenical pyrites at *Reichenstein*, in the circle of *Glatz*. A mine of chrysolite exists in the mountain of *Kosennitz*.

MINES OF THE CENTRE OF FRANCE.

The antient formations, principally granitic, which constitute the ground of several departments of the centre and south of France, are hardly any richer in explorations than the districts mentioned at the end of the *Black Forest*. Only some insulated mines are to be observed here, of which a very few possess any importance. These all occur towards the eastern border of the mass of primitive formations, in a zone characterised by a great abundance of schistose rocks.

At *Villefort* and at *Viallaze*, in the department of the *Lozère*, and in some places adjoining, several veins of argentiferous galena are worked which traverse the gneiss and the granite. These mines, remarkable at present for the regularity of their workings, employ 300 labourers, and produce annually about 220,000 lbs. avoird. of lead, and 1600 marks of silver.

The city of *Vienne*, in *Dauphiny*, is built on a hill of gneiss separated by the *Rhone* from the main body of the primitive formations, and in which veins of galena occur, which are now imperfectly mined. Other lead mines of less importance are observed at *St. Julien-Molin-Molette*, department of the *Loire*, and at *Jour*, department of the *Rhone*.

At *Chessy*, a village situated 7 leagues N. W. of *Lyons*, there occur in a talcose schist very extensive veins of cupreous pyrites, by no means rich, but which have, nevertheless, been worked successfully during the latter part of the 18th century, and several years of the present. At that period, there was found in a sandstone which covers the talcose schist, and which appears referrible to the red sandstone or the variegated sandstone, a bed containing a great quantity of blue carbonate of copper and protoxide of copper, to the working of which the miners have since directed their principal attention. There exists at *Saint-Belle*, 2 leagues to the south of *Chessy*, a deposit of copper pyrites like that of *Chessy*, which was at one time worked, but is now standing still. At *Romanéscho*, in the department of *Saone et Loire*, a very abundant deposit of oxide of manganese is observed, apparently forming a mass in the granite, or perhaps above it. The workings are very irregular.

In the mountain of *Ecouchettes* near *Couches*, in the same department, an ore of oxide of chrome has been occasionally worked.

At *Malbose*, in the department of the *Lozère*, a feeble vein of sulphuret of antimony is mined.

There are also in the centre of France some explorations of galena, antimony, and manganese, which appear to be of too little importance to be noticed in detail.

Some years ago a tin ore was discovered at *Vaubry*, six leagues N. N. W. of *Limoges*. At present researches are making with a view of discovering deposits of such magnitude as to pay the expense of working it.

MINES OF THE NORTH OF PORTUGAL AND THE ADJOINING PARTS OF SPAIN.

The *Carthaginians* appear to have worked tin mines in this part of the Peninsula. It is said that some formerly existed in Portugal, in the environs of *Viseu*, a province of *Beira*, at

a place called *Burraco de Stanno*. Some veins of the same metal were discovered in 1787, near Monte-Rey, in the south of Galicia. They were fully two yards thick, and were incased in granite. This province presents also deposits of sulphuret of antimony. Some analogous ores are found in Castille and Estremadura. Lead ores were worked in the last century not far from Mogadouro, on the banks of the Sabor, in the province of Tras-los-Montes, and near Longroiva on the banks of the Rio-Prisco. Mines of plumbago occur near Mogadouro. There are also some iron mines in the same country near Felguiera and Torredelemnacorro. They supply the iron-works of Chapa-cunha. Two very ancient establishments of the same kind exist in the Estremadura of Portugal; the one in the district of Thomar, and the other in that of Figuiero dos Vinhoss: they are supplied by mines of red oxide of iron, situated on the frontiers of this province and of Beira. One deposit of quicksilver ore occurs at Couna in Portugal. At Rio Tinto in Spain, on the frontiers of Portugal, there is a copper mine which produces about 33,000 *lbs. avoird.* of this metal per annum. The ore is a copper pyrites. The mountains in the environs of Oporto present everywhere indications of the ores of copper and other metals; and it appears that all this part of the Peninsula is in general rich in metallic treasures, but that the want of wood prevents their being mined to advantage.

Besides, many of the deposits which originally existed there must be in a great measure exhausted. It was in these countries chiefly that the gold and silver mines lay, which the Carthaginians and Romans worked with so much advantage, and contested in so keen a manner. Near Loria (the ancient Numantium), Azagala, and Burgos, considerable vestiges of the ancient workings may still be seen.

MINES OF BRITANNY.

Britanny has hardly a better share in mineral wealth than the countries we have just passed in review. There exist in it at this moment only two important exploitations; which are, the lead mines of *Poullaouen* and *Huelgoat*, situated near Carhaix. The mine of *Huelgoat*, celebrated for the plumb-gomme (hydro-aluminate) discovered in it, is opened on a vein of galena, which traverses transition rocks. The workings have subsisted for about three centuries, and have attained to a depth of 220 yards. The vein of *Poullaouen*, called the New Mine, was discovered in 1741. It was powerful and very rich near the surface; but it became subdivided and impoverished with its depth, notwithstanding which the workings have been sunk to upwards of 180 yards below the surface. In these mines there are fine hydraulic machines for the drainage of the waters, with wheels from 14 to 15 yards in diameter; and water-pressure machines have been recently constructed. The mines employ more than 900 workmen, and furnish annually more than 1,200,000 *lbs. avoird.* of lead, several thousand pounds of copper, and 2000 marks, or 1034 *lbs. avoird.* of silver. These are the most important metallic mines of France. Several veins of galena exist at *Chatelaudren*, near Saint-Briex, but they are not worked at present. There is also one at Pompean, near Rennes, which has been worked to a depth of 140 yards, but is in like manner now abandoned. It affords, besides the galena, a very large quantity of blende (sulphuret of zinc), of which attempts are making to take advantage. There occurs, also, a lead mine at Pierreville, department of the Channel, in a formation connected with the system of Brittany. It is opened on a vein which traverses a limestone pretty analogous to that of Derbyshire. The same department presents a deposit of sulphuret of mercury at Ménildot. A few years ago, some tin ore was discovered at Pyriac, near Guérande, in the department of the Loire Inférieure, but the researches since made to find workable deposits have been unsuccessful. A mine of antimony was worked at La Ramée, department of La Vendée. Several of the coal deposits lately mined in the departments of La Sarthe, La Mayenne, and Mayenne-et-Loire, ought probably to be regarded as more ancient than the genuine coal measures.

Table of the Production of the French Mines, during the year 1832.*

| Species of Mine. | Number of Mines. | Extent of Surface conceded, | Number of Workmen. | Production is in 10ths of a ton. | Value of the rough product in francs. |
|-----------------------------|------------------|-----------------------------|--------------------|----------------------------------|---------------------------------------|
| <i>Metallic Substances.</i> | | <i>Kilom. carrés.</i> | | | |
| Antimony - | 16 | 93,8954 | 130 | Melted antim. 1·030 98 | 71·232,75 |
| Copper - - | 8 | 274,18 | 258 | Black copper 1·376 | 247·680 |
| Iron - - - | 131 | 1·051,391 | 8917 | Rough ore 15·814,690 | 3,630·806,81 |
| Manganese - | 8 | 16,54 | 66 | 6·087 | 66·849,88 |
| Gold - - - | 1 | 0·49 | | | |
| Lead and Silver - | 33 | 614,23 | 1259 | 8·505 | 742·051 |
| Zinc - - - | 1 | 6,80 | | | |

* (*Annales des Mines*, tom. v., 1834, p. 676.)

MINES OF THE CORRESPONDING COASTS OF GREAT BRITAIN AND IRELAND.

The mines comprehended in this section are situated, 1. in Cornwall and Devonshire; 2. in the S. E. of Ireland; 3. in the island of Anglesey and the adjoining part of Wales; 4. in Cumberland, Westmoreland, the north of Lancashire, and the Isle of Man; 5. in the south of Scotland; 6. in the middle part of the same country.

Cornwall and Devonshire present three principal mining districts; viz. the portion of Cornwall situated in the environs and S.W. of Truro, the environs of St. Austle, and the environs of Tavistock.

The first of these districts is the most important of the three in the number and richness of its mines of copper, tin, and lead. The ores of copper, which consist almost entirely of copper pyrites and common sulphuret of copper, constitute very regular veins running nearly from east to west, and incased most frequently in a clay-slate of a talcose or hornblende nature, called *killas*, and sometimes in granite, which forms protuberances in the middle of the schists. The tin occurs principally in veins, which, like the preceding, traverse the killas and the granite. They are also very often directed nearly from east to west, but they have a different inclination, or dip, from that of the copper veins, which cut them across and interrupt them, and are consequently of more recent formation. The tin ore forms also masses, which appear most usually attached to the veins by one of their points. Lastly, it is found in small veins which traverse the granite, principally near the points where this rock touches the killas. Certain veins present the copper and tin ores together; a mixture which occurs chiefly near the points of intersection of the two metallic veins. Certain mines furnish at once both copper and tin; but the most part produce in notable quantity only one of these metals. The most important copper mines are situated near Redruth and Camborn; amongst which may be noted particularly those called *Consolidated Mines*, *United Mines*, Huel-Alfred, Dolcoath, Poldice, &c. The principal tin mines are situated still farther to the south-west, near Helston, Saint-Yues, &c. Those called Huel Vor, Great Huas, are particularly noticed. There are several mines in Cornwall, of which the crossing veins which at once intersect and throw out the veins of copper and tin, contain argentiferous galena and several ores of silver. There existed formerly mines of argentiferous lead near Helston and Truro. There may be now seen near Saint Michael an ore which, melted and cupelled on the spot, yields from an ounce and a half to two ounces of silver per quintal. Near Calstock a silver mine is worked, called *Huel-Saint-Vincent*, which has afforded, it is said, in some months, from 900 to 1000 *lbs. avoird.* of that metal. The ore, consisting of hornsilver and native silver, is treated on the spot.

In the environs of Saint Austle, the copper mines of *East Crinnis* and *West Crinnis* deserve to be noticed, as well as the tin mine of Polgooth, opened on a tin vein; and the mine of Carclaise, explored in the open air on a system of small veins of this metal.

Near Tavistock there occur mines of copper, tin, and lead. Among the last may be remarked particularly that called *Huel Betsey*, of which the ores melted and cupelled on the spot, afford an ounce and a half of silver per cwt.; and that of Beeralston, whose ore is sent to Bristol to be smelted there. It yields from four to five ounces of silver per cwt.

There are mines of antimony at *Huel-Boys* in Devonshire, and at Saltash in Cornwall.

The tin and copper ores of Cornwall are accompanied with arsenical pyrites, which is turned to some account by the fabrication of white arsenic (arsenious acid).

Cornwall and Devonshire produce annually about 6,160,000 *lbs. avoird.* of tin; 18,700,000 *lbs. avoird.* of copper; and 1,760,000 *lbs. avoird.* of lead. See COPPER and TIN.

The tin is treated at the mine localities; but the copper ores are sent in their natural state to Swansea in South Wales, to be smelted.

Wood and labour being very dear in Cornwall and Devonshire, the mineral deposits of these counties cannot be worked out so completely, nor can the mechanical preparation of the ores be so far pushed, as in several other parts of the world. But all the operations which appear advantageous are conducted in the most judicious, most economical, and most expeditious manner. Steam engines are erected there, some of them possessing the power of several hundred horses. Many of the mines are explored to a depth of upwards of 400 yards; and several are celebrated for the boldness of their workings. The one called *Botallack* Mine, situated in the parish of St. Just, near the Cornwall cape, is opened amid rocks which form the sea-coast, and stretches several hundred yards under the sea, and upwards of 200 yards beneath its level. In some points so small a thickness of rock has been left to support the weight of the waters, that the rolling of pebbles on the bottom is distinctly heard by miners during a storm. The mine of Huel-werry, near Penzance, was worked by means of a single shaft opened on the coast, in a space left dry by the sea only for a few hours at every ebb. A small wooden tower was built over the mouth of the shaft, which, being carefully caulked, kept out

the waters of the ocean when the tide rose, and served to support the machines for raising the ore and drainage. A vessel driven by a storm overturned it during the night, and put a period to this hazardous mode of mining, which has not been resumed.

The most considerable mines of Ireland are those of Cronebane and Tingrony, and of Ballymartagh, situated three leagues S. W. of Wicklow, in the county of the same name. Their object is to work the copper pyrites, accompanied with some other ores of copper, galena, sulphuret of antimony, as well as pyrites of iron, which forms several flattened masses in the clay-slate. Pretty extensive workings have been made here; and the ore was transported in its natural state to Swansea. Veins or masses of copper pyrites and galena are mined in some other points of the south-east of Ireland, but none of them with any notable advantage. The principal is the lead mine situated in the county of Tipperary, near the village called Silver Mines, absurdly enough, because, though silver was sought for in the lead, none was extracted. Many iron mines anciently existed in Ireland, but the destruction of the forests has considerably diminished their number and activity, so that only a few remain in Kilkenny, Wicklow, and Queen's County.

The isle of Anglesey is celebrated for its copper mines, the principal of which are Mona-mine and Farys-mountain. The ore is a copper pyrites, sometimes of considerable volume, lying in masses in a formation containing serpentine and different talcose rocks. For a long time the workings were carried on in the open air, but the exterior exploration has been thereby compromised. The neighbouring coasts of Wales present some mines of the same nature. All the ores are treated in a smelting-house established in the isle of Anglesey. The formation of slate-clay and greywacke, which constitutes the greater part of Wales, and some of the adjoining districts of England, includes several lead mines, of which we shall presently speak in noticing those of far greater importance contained in the more recent limestone formations of the same regions.

Pretty important mines of copper pyrites and red hematitic iron are worked in Westmoreland, and in the neighbouring parts of Cumberland and Lancashire. The copper ores, and a portion of the iron ones, are embarked for Swansea. The rest of the iron ore is treated on the spot in blast furnaces supplied with wood charcoal. The isle of Man affords indications of lead, copper, and iron in the mountains of Snafie, which constitute its centre. At Borrowdale in Westmoreland, a mine of graphite (plumbago) has been worked for a long period. It furnishes the black lead of the English pencils, so celebrated over the world. The mineral occurs in mass in a talcose formation.

There are famous lead mines in the south of Scotland, at Leadhills in Lanarkshire; the veins of which are incased in greywacke. Some manganese has also been found. At Cally, in Kirkcudbrightshire, a copper mine has been lately discovered; and a mine of antimony has been known for some time at West Kirk in Dumfriesshire; but neither has been turned to good account.

In the middle part of Scotland, the lead mines of Strontian in Argyleshire deserve to be noticed, opposite to the north-east angle of the isle of Mull. They are opened on veins which traverse gneiss. According to Mr. John Taylor, these mines and those of Leadhills produce annually 5,610,000 *lbs. avoird.* of lead.

Explorations of manganese were begun at Grantown on the banks of the Don, a river which falls into the German Ocean at Aberdeen. A mine of coarse graphite has also been worked at Huntley.

A copper mine was discovered some years back in one of the Shetland isles; and chromate of iron is now extensively worked there in serpentine and talc.

MINES OF THE NORTH OF EUROPE.

These mines are situated for the most part in the south of Norway, towards the middle of Sweden, and in the south of Finland, a little way from the shortest line drawn from the lake Onega to the south-west angle of Norway. A few mines occur in the northern districts of Norway and Sweden. The main products of these several mines are iron, copper, and silver.

The iron mines of Norway lie on the coasts of the Gulph of Christiania, and on the side facing Jutland, principally at Arendal, at Krageroe, and the neighbourhood. The ores consist almost solely of black oxide of iron, which forms beds or veins of from 4 to 60 feet thick, incased in gneiss, which is accompanied with pyroxène (augite), epidotes, garnets, &c. These iron ores are reduced in a great many smelting forges, situated on the same coast, and particularly in the county of Laurwig. Their annual product is about 16½ millions of pounds *avoird.* of iron, in the form of cast iron, bar iron, sheet iron, nails, &c.; of which one half is exported.

Norway possesses rich copper mines, some of which lie towards the south and the centre of the country, but the most considerable occur in the north, at *Quikkse, Løken, Selboe, and Raraas*, near Dronheim. The mine of *Rærnas*, 16 miles from Dronheim to

the S. E. of this city, is opened on a very considerable mass of copper pyrites, and has been worked in the open air since 1664. It has poured into the market from that time, till 1791, 77 millions of pounds avoird. of copper. In 1805, its annual production was 864,600 lbs.; while all the other mines of Norway together do not furnish quite one-fourth of that amount.

Norway comprehends also some celebrated silver mines. They are situated from 15 to 20 leagues S. W. of Christiania, in a mountainous country near the city of Kongsberg, which owes to them its population. Their discovery goes back to the year 1623, and their objects are veins of carbonate of lime, accompanied with asbestos and other substances in which native silver occurs, usually in small threads or networks, and sometimes in considerable masses, along with sulphuret of silver. These veins are very numerous, and run through a considerable space, divided into four districts (arrondissemens), each of which contains more than 15 distinct explorations. When a new mine is opened, an excavation in the open air is first made, which embraces several veins, and they then prosecute by subterranean workings only those that appear to be of consequence. The workings do not exceed 1000 feet in depth. Fire is employed for attacking the ore. In 1782, the formation of a new gallery of efflux was commenced, destined to have a length of 10,000 yards, and to cost 60,000*l*. These mines, since their discovery till 1792, have afforded a quantity of silver equivalent to four millions of pounds sterling. The year 1768 was the most productive, having yielded 38,000 marcs of silver. At present they give but a very slender return; in 1804 they were threatened with a complete abandonment. The ore is treated by fusion; the lead necessary for this operation being imported from England. There are, however, lead and silver mines in the county of Jarlsberg, but they are very slenderly worked.

At *Edswald*, 50 leagues N. of Christiania, a mine is worked of auriferous pyrites, with a very inconsiderable product.

Cobalt mines may be noticed at Modum or Fossum, 8 leagues W. of Christiania; they are extensive, but of little depth.

Lastly, graphite is explored at *Engidal*; and chromite of iron deposits have been noticed in some points of Norway.

The irons of Sweden enjoy a merited reputation, and form one of the chief objects of the commerce of that kingdom. Few countries, indeed, combine so many valuable advantages for this species of manufacture. Inexhaustible deposits of iron ore are placed amid immense forests of birches and resinous trees, whose charcoal is probably the best for the reduction of iron. The different groups of iron mines and forges form small districts of wealth and animation in the midst of these desolate regions.

The province of Wermeland, including the north bank of the lake Wener, is one of the richest of Sweden in iron mines. The two most important are those of Nordmarck, 3 leagues N. of Philipstadt, and those of Persberg, 2½ leagues E. from the same city. Philipstadt is about 50 leagues W. ¼ N. W. from Stockholm. Both mines are opened on veins or beds of black oxide of iron several yards thick, directed from N. to S. in a ground composed of hornblende, talcose and granitic rocks. These masses are nearly vertical, and are explored in the open air to a depth of 130 yards. Formerly this exploitation was effected by iron wedges and pickaxes; but they have been superseded by gunpowder, since 1650. The province of Wermeland, and that of Dahl which adjoins it, forming the west border of the Wener lake, contained in 1767, 48 smelting cones, each going from 4 to 5 months every year.

The principal iron mines of Rosslagie (part of the province of Upland) are those of Dannemora, situated 11 leagues from Upsal. They stand in the first rank of those of Sweden, and even of Europe. The masses worked upon are flattened and vertical, running from N. E. to S. W., and are incased in a ground formed of primitive rocks, among which gneiss, petrosilex and granite are most conspicuous. They amount to three in number, very distinct, and parallel to each other; and are explored through a length of more than 1500 yards, and to a depth of above 80, by the employment of fire, and blasting with gunpowder. The explorations are mere quarries; each presenting an open trench 65 yards wide, by a much more considerable length, and an appalling depth. Magnetic iron ore is extracted thence, which furnishes the best iron of Sweden and Europe; an iron admirably qualified for conversion into steel. In 1767, these minings supplied for a long time, 15 smelting cones situated in Rosslagie, at a distance of 10 leagues.

The island of Utoe, situated near the coast of the province of Upland, presents also rich iron mines. The protoxide of iron there forms a thick bed in the gneiss. It is worked in trenches far below the level of the sea. The ore cannot be smelted in the island itself; but is transported in great quantities to the continent.

The province of Smoland includes also very remarkable mines. Near Jonköping, a hill called the *Tabery* occurs, formed in a great measure of magnetic black oxide of iron, contained in a greenstone reposing on gneiss.

In several parts of Lapland, the protoxide of iron occurs in great beds, or immense masses. At Gellivara, 200 leagues N. of Stockholm, towards the 67th degree of latitude, it constitutes a considerable mountain, into which an exploitation has been opened. The iron is despatched on small sledges drawn by rein-deer to streams which fall into the Lutea; and thence by water carriage to the port of Lutea, where it is embarked for Stockholm.

There are a great many iron works in Dalecarlia, but a portion of the ores are got from alluvial deposits. Similar deposits exist also in the provinces of Wermeland and Smoland.

The mines and forges of Sweden produce annually about 165 millions of pounds avoird. (74,000 tons nearly) of cast iron or bar iron; of which two thirds are exported chiefly from the harbours of Stockholm, Gottenburg, Geffle, and Norkoping.

The copper mines of Sweden are scarcely less celebrated than its iron mines. The principal is that of Fahlun or Kopparberg, situated in Dalecarlia, near the town of Fahlun, 40 leagues N. W. of Stockholm. It is excavated in an irregular and very powerful mass of pyrites, which in a great many points is almost entirely ferruginous, but in others, particularly near the circumference, it includes a greater or less portion of copper. This mass is enveloped in talcose or hornblende rocks. More to the west, there are three other masses almost contiguous to each other, which seem to bend in an arc of a circle around the principal mass. They are explored as well as the last. This was at first worked in the open air; but imprudent operations having caused the walls to crumble and fall in, since 1647 the excavation presents near the surface nothing but frightful precipices. The workings are now prosecuted by shafts and galleries into the lower part of the deposit, and have arrived at a depth of 194 fannars (nearly 430 yards). They display excavations spacious enough to admit the employment of horses, and the establishment of forges for repairing the miners' tools. It is asserted that the exploration of this mine goes back to a period anterior to the Christian era. During its greatest prosperity, it is said to have produced 11 millions of pounds avoird. of copper annum, or about 5000 tons. It furnishes now about the seventh part of that quantity; yielding at the same time about 70,000 lbs. of lead, with 50 marcs of silver, and 3 or 4 of gold. The ores smelted at Fahlun produce from 2 to 2½ of copper per cent. But the extraction of the metal is not the sole process; the sulphur is also procured; and with it, or the pyrites itself, sulphuric acid and other chemical products are made. Round Fahlun, within the space of a league, 70 furnaces or factories of different kinds may be seen. The black copper obtained at Fahlun is converted into rose copper, in the refining hearths of the small town of *Ofwostad*.

In the copper mine of *Garpenberg*, situated 18 leagues from Fahlun, there occur 14 masses of ore quite vertical, and parallel to each other, and to the beds of mica-slate or talc-slate, amid which they stand. This mine has been worked for more than six hundred years.

The mine of *Nyakopparberg*, in Nericia, 20 leagues W. of Stockholm, presents masses of ores parallel to each other, the form and arrangement of which are very singular. It is worked by open quarrying, and with the aid of fire.

We may notice also the copper mines of *Atwidaberg*, in Ostrogothia, which furnish annually the sixth part of the whole copper of Sweden.

There are several other copper mines in Sweden. Their whole number is ten; but it was formerly more considerable. They yield at the present day in all, about 2,420,000 *lbs. avoird.* (1000 tons) of copper.

The number of the silver mines of Sweden has in like manner diminished. In 1767, only 3 were reckoned under exploration, viz. that of *Hellefors* in the province of Wermeland; that of *Segersfors* in Nericia; and that of *Sahlia* or *Sahlberg*, in Westmannia, about 23 leagues N. W. of Stockholm. The last is the only one of any importance. It is very ancient, and passes for having been formerly very productive; though at present it yields only from 4 to 5000 marcs of silver *per annum*. Lead very rich in silver is its principal product. It is explored to a depth of more than 200 yards. The soundness of the rock has allowed of vast excavations being made in it, and of even the galleries having great dimensions; so that in the interior of the workings there are winding machines, and carriages drawn by horses for the transport of the ores.

At *Sahlberg*, there are deposits of sulphuret of antimony.

For the last 30 or 40 years mines of cobalt have been opened in Sweden, principally at *Tunaberg* and *Los*, near *Nyköping*, and at *Otward* in Ostrogothia. The first are worked upon veins of little power, which become thicker and thinner successively; whence they have been called *bead-veins*. It appears that the products of these mines, though of good quality, are inconsiderable in quantity.

Lastly, there is a gold mine in Sweden; it is situated at *Adelfors*, in the parish of *Alsfeda*, and province of Smoland. It has been under exploration since 1737, on veins of auriferous iron pyrites, which traverse schistose rocks; presenting but a few inches

of ore. It formerly yielded from 30 to 40 marks of gold *per annum*, but for the last few years it has furnished only from 3 to 4.

The mines and smelting works of Sweden gave annually, in 1809, a gross product worth 1,463,600*l*.

The south of Finland and the bordering parts of Russia contain some mines, but they are far from having any such importance as those of Sweden.

At Orijerwy near Helsingfors, a mine of copper occurs whose gangue is carbonate of lime, employed as a limestone.

Near Cerdopol, a town situated at the N. W. extremity of the Ladoga lake, veins of copper pyrites were formerly mined.

Under the reign of Peter the Great, an auriferous vein was discovered in the granitic mountains which border the eastern bank of the lake Ladoga, near Olonetz. It was rich only near the surface; and its working was soon abandoned.

Latterly, an attempt has been made to mine copper and iron ores near Eno, above and to the N. W. of Cerdopol, but with little success.

Some time ago rich ores of iron, lying in veins, were worked near the lake Shuyna, N. W. from Cerdopol; but this mine has been also relinquished.

On the west bank of the Onega lake, there is an iron work at Petrazavodsk, called a *zavode*, which is the greatest establishment of this kind existing in the north of Russia.

Nothing is now reduced there except bog iron ore, or swamp ore extracted from small lakes in the neighbourhood.

The transition limestone which constitutes the body of Esthonia contains lead ore at *Avoosaar* near *Fellin*. These ores were worked when these provinces belonged to the Swedes. It was attempted in 1806 to resume the exploitation, but without success.

MINES OF THE ALLEGHANY MOUNTAINS.

The chain of the Alleghanys, which traverses the United States of America from N. W. to S. E. parallel to the coasts of the Atlantic Ocean, includes a considerable number of deposits of iron, lead, and copper ores; along with some ores of silver, plumbago, and chromite of iron. Attempts have been made to mine a great many of these deposits; but most of these have been unsuccessful.

A bed of black oxide of iron occurs in gneiss near Franconia in New Hampshire. It has a power of from 5 to 8 feet; and has been mined through a length of 200 feet, and to a depth of 90 feet. The same ore is found in veins in Massachusetts and Vermont, accompanied by copper and iron pyrites. It is met with in immense quantities on the western bank of the lake Champlain, forming beds of from 1 to 20 feet in thickness, almost without mixture, encased in granite. It is also found in the mountains of that territory. These deposits appear to extend without interruption from Canada to the neighbourhood of New York, where an exploration on them may be seen at Crown-Point. The ore there extracted is in much esteem. Several mines of the same species exist in New Jersey. The primitive mountains which rise in the north of this state near the Delaware, include a bed almost vertical of black oxide of iron, which has been worked to 100 feet in depth. In the county of Sussex the same ore occurs, accompanied with Franklinite. At New Milford in Connecticut, a pretty abundant mine of sparry iron occurs; the only one of the kind known in the Alleghanys. The United States contain a great many iron works, some of which prior to the year 1773, sent over iron to London. They are principally supplied from alluvial iron ore.

The most remarkable lead mines of the Alleghanys, are those of Southampton in Massachusetts, and of Perkiomen Creek in Pennsylvania, 8 leagues from Philadelphia. The first furnishes a galena, slightly argentiferous; an ore accompanied with various minerals, with base of lead, copper, and zinc, and with *gangues* (vein-stones) of quartz, sulphate of baryta, and fluor spar. These substances form a vein which traverses several primitive rocks, and is said to be known over a length of more than 6 leagues. At Perkiomen Creek a vein of galena is mined, which traverses a sandstone, referred by many geologists to the old red sandstone. Along with galena a great variety of minerals is found with a basis of lead, zinc, copper, and iron. The mines of lead worked in Virginia, on the banks of the Kanhawa, deserve also to be mentioned.

None of the copper mines actually in operation in the United States seem to merit particular attention. The mine of Schuyler in New Jersey had excited high hopes, but after the workings had been pushed to a depth of 300 feet, they have been for some years abandoned. The ore, which consisted of sulphuret of copper, with oxide and carbonate of copper, occurred in a red sandstone.

In some points of the Alleghanys, deposits have been noticed of chromite of iron and graphite.

Coal-measures occur in several points of the United States, especially on the N. W

slope of the Alleghany mountains. The coal is mined successfully on the banks of the Ohio, towards the upper part of its course. See ANTHRACITE.

MINES OF THE SOUTH OF SPAIN.

The mountains which separate Andalusia from Estremadura, Leon and La Mancha, and those of the kingdoms of Murcia and Grenada, include some celebrated mines.

We shall mention first the silver mines of *Guadalecanal* and *Cazalla*, situated in the Sierra-Morena, 15 leagues N. of Seville. Among the ores, red silver and argentiferous gray copper have been specified. Their product is inconsiderable; but this territory presented formerly much more important mines at Villa-Guttierra, not far from Seville. At the beginning of the 17th century they are said to have been worked with such activity, that they furnished daily 170 marcs of silver. More to the east, there exists in the mountains of La Mancha, a mine of antimony, at Santa-Cruz-de-Mudela. On the southern slope of the Sierra-Morena, very important lead mines occur, particularly at Linares, 12 leagues N. of Jaen. The veins are very rich near the surface, which causes them not to be mined much in depth; so that the ground is riddled, as it were, with shafts. More than 5000 old and new pits may be counted; the greater part of which is ascribed to the Moors. Six of these mines are now explored on account of the crown, and they produce on an annual average, according to M. Laborde, 1,320,000 *lbs. avoird.* (about 600 tons) of lead, which is too poor in silver for this precious metal to be extracted with advantage. Bowles states, that there was found at the mines of Linares, a mass of galena, whose dimensions were from 21 to 24 yards in every direction. Abundant mines of zinc occur near Alcaras, 15 leagues N. E. of Linares; which supply materials to a brass manufactory established in that town. There are also lead mines in the kingdoms of Murcia and Grenada. Very productive ores have been worked for some time near Almeria, a harbour situated some leagues to the west of the cape of Gates. The ore is in part treated on the spot with coal brought from Newcastle, and in part sent to Newcastle to be reduced there. The kingdoms of Murcia, Grenada, and Cordova, include several iron mines. Near Casalla and Ronda, in the kingdom of Grenada, mines of plumbago are explored.

On the northern flank of the Sierra-Morena, lie the famous quicksilver mines of Almaden, situated near the town of the same name in La Mancha. They consist of very powerful veins of sulphuret of mercury, which traverse a sandstone, evidently of a geological age as old at least as the coal formation. Hard by, beds of coals are mined.

MINES OF THE PYRENEES.

The Pyrenees and the mountains of Biscay, of the Asturias, and the north of Galicia, which are their prolongation, are not very rich in deposits of ores. The only important mines that occur there, are of iron; which are widely spread throughout the whole chain, except in its western extremity. We may mention particularly in Biscay, the mine of *Sommarastro*, opened on a bed of red oxide of iron; and in the province of Guipuscoa, the mines of Mondragon, Oyarzun, and Berba, situated on deposits of sparry iron. There are several analogous mines in Arragon and Catalonia. In the French part of the Pyrenees, veins of sparry iron are worked which traverse the red sandstone of the mountain Ustelleguy, near Baygorry, department of the Basses-Pyrenees. The same department affords in the valley of Asson the mine of Haugaron, which consists of a bed of hydrate of iron, subordinate to transition limestone. The deposit of hydrate of iron, worked for an immemorial time at Rancié, in the valley of Viedessos, department of the Arriège, occurs in a similar position. The ancient workings have been very irregular and very extensive; but the deposit is still far from being exhausted. There are also considerable mines of sparry iron at *Lapinouse*, at the tower of Batera, at Escaron, and at Fillols, at the foot of the *Canigou*, in the department of the Oriental Pyrenees. The iron mines of the Pyrenees keep in activity 200 Catalanian forges. Although there exists in these mountains, especially in the part formed of transition rocks, a very great number of veins of lead, copper, cobalt, antimony, &c., one can hardly mention any workings of these metals; and among the abandoned mines, the only ones which merit notice are, the mine of argentiferous copper of *Baygorry*, in the department of the Low Pyrenees, the lead and copper mine of *Aulus*, in the valley of the Erce, department of the Arriège, and the mine of cobalt, of the valley of Gistain, situated in Arragon, on the southern slope of the Pyrenees. It is asserted, however, that a lead mine is in actual operation near Bilboa in Biscay. The mines of plumbago opened at Sahun in Arragon, should not be forgotten. Analogous deposits are known to exist in the department of the Arriège, but they are not mined.

MINES OF THE ALPS.

The mines of the Alps by no means correspond in number and richness with the extent and mass of these mountains. On their eastern slope, in the department of the

high and the low Alps, several lead and copper mines are mentioned, all inconsiderable and abandoned at the present time, with the exception of some workings of galena, which furnish also a little graphite.

During some of the last years of the 18th century, there was mined at *la Gardette* in the *Oisans*, department of the *Isère*, a vein of quartz which contained native gold and auriferous pyrites; but the product has never paid the expenses, and the mine has been abandoned. The *Oisans* presented a more important mine, but it also has been given up; it was the silver mine of *Allemont* or *Chalanches*. The ore consisted of different mineral species more or less rich in silver, disseminated in a clay which filled the clefts and irregular cavities in the middle of talcose and hornblende rocks. This mine yielded annually towards the conclusion of the 18th century, so much as 2000 marcs of silver; along with some cobalt ore. Among the great number of mineral species, which occurred in too small quantities to be worked to advantage, there was native antimony, sulphuret of mercury, &c. The *Oisans* present, moreover, some rather unproductive mines of anthracite. Mines of an analogous nature, but more valuable, are in activity at the western foot of the Alps, at *la Mothe*, *Notre-des-Vaux* et *Putteville*, a few leagues S. E. of Grenoble.

From the entrance of the valley of the *Oisans* to the valley of the *Arc* in Savoy, there occur on the N. W. slope of the Alps, a great many mines of sparry iron. The locality of this ore is here very difficult to define. It appears to form sometimes beds or masses, and sometimes veins amid the talcose rocks. Some is also found in small veins in the first course of the calcareous formation which covers these rocks. These mines are very numerous, the most productive occur united in the neighbourhood of *Allevard*, department of the *Isère*, and of *Saint Georges d'Huretières* in Savoy. Those of *Formevaux* and *Laprat*, in the latter country, are also mentioned. The irregularity of the mining operations surpasses that of the deposits. The mines have been from time immemorial in the hands of the inhabitants of the adjoining villages, who work in them, each on his own account, without any pre-arrangement, or other rule than following the masses of ore which excite hopes of the most considerable profit in a short space of time. What occurs in almost every mine of sparry iron, is also to be seen here, most imprudent workings. The mine called the *Grande Fosse*, at *Saint Georges d'Huretières*, is prolonged without pillars or props, through a height of 130 yards, a length of 220 yards, and a breadth equal to that of the deposit, which amounts in this place to from 8 to 13 yards; thus a void space is exhibited of nearly 300,000 square yards. The sparry iron extracted from these different mines supplies materials to 10 or 12 smelting furnaces, the cast iron of which, chiefly adapted for conversion into steel, is manufactured in part in the celebrated steel works of *Rives*, department of the *Isère*. There occurs in some parts of the mines of *Saint Georges d'Huretières* copper pyrites, which is smelted at *Aiguebelle*.

Savoy presents celebrated lead mines at *Pescy* and at *Macot*, 7 leagues to the E. of *Moutiers*. Galena, accompanied with quartz, sulphate of baryta, and ferriferous carbonate of lime, occurs in mass in talcose rocks. The mine of *Pescy* had been restored to activity by the French government, which established there a practical school of mines; and in its hands the mine produced annually as much as 440,000 *libs. avoird.* of lead, and 2500 marcs of silver. It is now explored on account of the king of Sardinia; but it begins to be exhausted, and yields less products. That of *Macot*, opened a few years ago, begins to give considerable returns. The mine of copper pyrites of *Servoz* in the valley of the *Arve*, may also be mentioned. The ore occurs both in small veins, and disseminated in a clay slate; but the exploration is now suspended. Lastly, slightly productive workings of anthracite are mentioned in several points of these mountains and in the conterminous portions of the Alps.

There exist in Piedmont some small mines of argentiferous lead. The copper mines of *Allagne*, and those of *Ollomont*, formerly yielded considerable quantities of this metal. Their exploration is now on the decline. The manganese mines of *Saint-Marcel* have few outlets; whence they have been feebly developed. Mines of plumbago, little worked, occur in the neighbourhood of *Finay* and in the valley of *Pellis*, not far from *Pignerol*. Some mines of auriferous pyrites have also been worked in this district of country; among others, those of *Macugnaga*, at the eastern foot of *Monte-Rosa*. The pyrites of this mine afforded by amalgamation only 11 grains of gold per quintal; and this gold, far from being fine, contained $\frac{1}{4}$ of its weight of silver. They became less rich in proportion as they receded from the surface. The explorations of auriferous pyrites in Piedmont are now abandoned, or nearly so. The only important mines in this country are those of iron. These generally consist of masses of black oxide of iron, of a nature analogous to those of Sweden; the principal ones being those of *Cogne* and *Traverselle*, which are worked in open quarries. Some others, less considerable, are explored by shafts and galleries. These ores are reduced in 33 smelting cupolas, 55 Catalan forges, and 105 refinery hearths. The whole produce about 10,000 tons of bar iron.

There is a mine of black oxide of iron, at present abandoned, at *Booernier*, near *Martigny*, in the *Valais*. There is also another iron mine at *Chamoissons*, in a lofty calcareous mountain on the right bank of the *Rhone*. The ore presents a mixture of oxide of iron and some other substances, of which it has been proposed to make a new mineral species, under the name of *Chamoisite*.

The district of the *Grisons* possesses iron mines with very irregular workings, situated a few leagues from *Coinre*.

The mountain of *Falkenstein*, in the *Tyrol*, formed of limestone and clay-slate, not far from *Schwatz*, a little below *Innsbruck*, in the valley of the *Inn*, contains mines of argenteriferous copper. At one of them, that of *Kütz-Pühl*, the workings reached, in 1759, according to the report of *MM. Jars* and *Duhamel*, nearly 1100 yards in depth; and were reckoned the deepest in Europe. But it was intended to abandon them. Analogous ores are explored in several other points of the same country. The most part of the products of these mines are carried to the foundry of *Brixlegg*, 4 leagues from *Schwatz*. The mines of the *Tyrol* furnished, on an average of years, towards 1759, 10,000 marcs of silver; at anterior periods, their product had been double; but now it is a little less. This region contains also gold mines whose exploration goes back a century and a half. They occur near the village of *Zell*, 8 leagues from *Schwatz*. The auriferous veins traverse clay-slates, and quartz rocks. Lately, a deposit of oxide of chrome, similar to that of the *Econchets* (*Saône* and *Loire*) has been discovered in the *Tyrol*. An unimportant mine of mercury has also been mentioned in that country, near *Brenner*.

In the territory of *Salzburg* there are some copper mines. In the environs of *Muerwinkel* and of *Gastein*, some veins are worked for the gold they contain; of which the annual return is valued at 118 marcs of this metal. There is an inconsiderable mine of quicksilver at *Leogang*.

In the *Tyrol* and in *Salzburg* there are iron mines in a very active state; principally those of *Kleinboden*, near *Schwatz*. But the portion of the Alps most abundant in mines of this metal, is the branch stretching towards Lower Austria. We find here, both in *Styria* and in *Austria*, a very great number of explorations of sparry iron. The deposits of the ores of sparry iron of *Eisenerz*, *Erzberg*, *Admont*, and *Vordenberg*, deserve notice. The latter are situated about 25 leagues S.W. of *Vienna*.

The southern flank of the Alps contains also a great many mines of the same kind, from the *Lago Maggiore* to *Carinthia*. Those situated near *Bergamo*, and those of *Huttenberg* and *Waldenstein*, in *Carinthia*, are especially mentioned.

All these mines of sparry iron are opened in the midst of rocks of different natures, which belong to the old transition district of the Alps. They seem to have close geological relations with those of *Alleverd*.

The branch of the Alps which extends towards *Croatia*, presents important iron mines, in the mountains of *Adelsberg*, 10 leagues S.W. from *Laybach* in *Carniola*.

The iron mines just now indicated in the part of the Alps that forms a portion of the Austrian states, supply materials to a great many smelting-works. In *Styria* and in *Carinthia*, more than 400 furnaces or forges may be enumerated, whose annual product is nearly 25,000 tons of iron. These two provinces are famous for the steel which they produce, and for the steel tools which they fabricate, such as scythes, &c. *Carniola* contains also a great many forges, and affords annually about 5000 tons of iron.

There are mines of argentiferous copper analogous to those of the *Tyrol*, at *Schladming* in *Styria*, at *Kirchdorf* in *Carinthia*, at *Agordo* in the territory of *Venice*, and at *Zamabor* in *Croatia*. The latter are remarkable for the great irregularity of the deposits, and for the richness of the copper pyrites that is mined; which produces 12 and sometimes 27 per cent. of copper. There are some deposits of antimony, mined to a trifling extent in *Carinthia*; and there are a few cobalt mines in *Styria*, not more actively worked. In the environs of *Raibel*, in *Carinthia*, mines of calamine exist, yielding annually about 200 tons of this substance. Of late, some of it has also been explored in *Styria*.

The limestones that cover the northern slopes of the Alps, present, like those of the departments of the lower and upper Alps, several lead mines of little consequence. They also include several celebrated mines of rock salt.

The analogous limestones which repose on the slopes of the Alps in *Carinthia*, and in the neighbouring provinces, afford likewise lead mines, especially near *Willach* and *Bleyberg*. These mines are very numerous, forming more than 500 *arrondissemens* of concessions. They furnish annually about 1800 tons of a lead too poor in silver to pay the expense of extracting that precious metal. At the mines of *Bleyberg*, the galena forms 14 beds or strata, inclined at an angle of from 40 to 50 degrees from the horizon, and alternating with a like number of calcareous strata. The latter are extremely full of shells. They of course belong to secondary limestone.

The limestones surmounting the southern slope of the Alps, contain also some lead mines; but the quicksilver mine of Idrja, situated at the foot of the Alps, 10 leagues N. W. of Trieste, is worthy of particular notice; it lies in a limestone which every thing leads us to refer to the *zschistein*, the most ancient of the secondary limestones.

The Apennines, which may be considered as a dependence of the Alps, present a small number of mines. At Chiavary and Pignone, manganese is mined; and at the beginning of the 18th century a vein of mercury was worked at Levigliani in Tuscany. An antimonial mine is mentioned at Pereta in the marshes of Sienna.

Before quitting these regions, we ought to notice the iron mines of the isle of Elba. They have been famous for 18 centuries; Virgil denotes them as inexhaustible, and supposes them to have been open at the arrival of Eneas in Italy. They are explored by open quarries, working on an enormous mass of specular iron ore, perforated with cavities bespangled with quartz crystals. The island possesses two explorations, called Rio and Terra-Nuova; the last having been brought into play at a recent period. The average amount extracted per annum is 15,000 tons of ore, which are smelted in the foundries of Tuscany, Liguria, the Roman states, the kingdom of Naples, and the island of Corsica.

There has been worked for a few years a mine of chromite of iron, at Carrada, near Gassinio, department of the Var.

MINES SITUATED IN THE SCHISTOSE FORMATIONS OF THE BANKS OF THE RHINE, AND IN THE ARDENNES.

The transition lands, which form, in the N. W. of Germany and in Flanders, a pretty extensive range of hills, include several famous mines of iron, zinc, lead, and copper. The latter lie on the right bank of the Rhine, in the territories of Nassau and Berg, at Baden, Augstbach, Rheinbreitenbach, and near Dillenburg. That of Rheinbreitenbach yielded formerly 110,000 lbs. avoird. of copper per annum, and those of the environs of Dillenburg now furnish annually 176,000 lbs. There are also some mines of argentiferous lead in the same regions. The most remarkable are in the territory of Nassau, such as those of Holzapfel, Pfingstviere, Löwenburg, and Augstbach on the Wiede, and Ehrental on the banks of the Rhine, which all together produce 600 tons of lead, and 3500 marcs of silver. To the above, we must add those of the environs of Siegen and Dillenburg, in the territories of Berg. A little cobalt is explored in the neighbourhood of Siegen, and some mines of the same nature are mentioned in the grand duchy of Hesse-Darmstadt, and in the duchy of Nassau Usingen.

But iron is the most important product of the mines on the right bank of the Rhine. Veins of hydrate of iron, or brown hematite, are explored in a great many points of Hessa, and the territory of Nassau, Berg, Marck, Tecklenbourg, and Siegen, along with veins or masses of sparry iron, and beds of red oxide of iron. We may note particularly; 1. The enormous mass of sparry iron, known under the name of Stahlberg, mined since the beginning of the 14th century in the mountain of Martinshardt, near Miissen, where imprompt excavations have occasioned, at several times, considerable downfallings of rubbish; 2. The abundant and beautiful mines of hydrate of iron and sparry iron on the banks of the Lahn and the Sayn, and among those of the mine of Bendorf; 3. The mine of Hohenkirchen in Hessa, where a powerful bank of manganeseiferous ore is worked, and where the mines are kept dry by a gallery more than one thousand yards long, walled over its whole extent. These several mines supply a great many iron works, celebrated for their steel, and for the objects of hardware, scythes, &c. fabricated there.

The Prussian provinces of the left bank of the Rhine, the duchy of Luxembourg and the Low Countries, include also many iron furnaces, of which a great number are supplied, in whole or in part, by ores of hydrate of iron, occasionally zinciferous, extracted from the transition rocks, where they form sometimes veins, and sometimes also very irregular deposits. A portion is explored by open quarrying, and a portion by underground workings. Some of these mines penetrate to a depth of 87 yards, and galleries may be observed in them cut in the form of vaults, and timbered with hooped stays. The Hundsrick, the Eiffel, and the territory of Luxembourg, present a great many of them.

The Eiffel formerly possessed important lead mines. Some still exist, which are feebly worked at Berncastle, 8 leagues below Trèves, on the banks of the Moselle. Those of Trarbach, situated two leagues lower, are now completely abandoned. The same holds with those of Bleyalf, which were opened on veins incased in the grey-wacke-slate, 9 leagues W. N. W. of Prüm, not far from the line of separation of the waters of the Moselle and the Meuse, in a district from which manufactures and comfort have disappeared since the mines were given up which sustained them.

More to the north a great many deposits of calamine occur. The most considerable,

and the one explored with most activity, is situated in the territory of Limburg (kingdom of the Netherlands), and known under the name of the *Great mountain*. It presents a mass about 45 yards wide, from 400 to 550 long, and of an unknown depth. The first labours, undertaken several centuries ago by the Spaniards, were executed by open quarrying, and pushed down 32 yards from the surface. The miners were obliged to renounce this mode of operation, and have since penetrated to the depth of 88 yards by means of subterranean workings. From 50 to 60 men work in this excavation, and extract annually from 700 to 800 tons of calamine, worth from 2400*l.* to 2700*l.* In the adjacent parts of the Prussian territory, not far from Aix-la-Chapelle, calamine is also mined, with ores of lead and iron, with which it is associated, in deposits regarded by M. Bouesnel, as analogous to the vein of Vedrin, to be noticed presently. The exploration is effected by means of small round shafts, from 34 to 44 yards deep, which are often wooded only with flexible branches of trees, or a kind of barrel-hoops. These workings may furnish annually from 1500 to 2000 tons of calamine, to the brass factories of Stollberg. On the right bank of the Rhine, in the country of la Marck, several small zinc mines furnish annually about 130 tons of calamine to the brass manufactures of Iserlohn.

The lead mine of Vedrin, alluded to above, lies at some distance N. of Namur. It is opened on a vein of galena nearly vertical, which crosses from N. to S. a limestone in nearly vertical strata, probably analogous into the limestone of Derbyshire. The vein is from 4 to 15 feet thick, and is recognised through a length of half a league. The mine, worked for two centuries, presents very extensive excavations; particularly a fine gallery of efflux. It has produced annually 900 tons of lead. At the present day the mine of Vedrin, and some adjoining exploitations, afford per annum only about 200 tons of lead, and 700 marks of silver.

MINES OF THE CALCAREOUS MOUNTAINS OF ENGLAND.

The limestone formation immediately subjacent to the coal measures, or the mountain limestone, constitutes almost alone several mountainous regions of England and Wales; in which three districts very rich in lead mines deserve to be noted.

The first of these districts comprehends the superior parts of the valleys of the Tyne, the Wear, and the Tees, in the counties of Cumberland, Durham, and York. Its principal mines are situated near the small town of Alston-Moor, in Cumberland. The veins of galena which form the object of the workings, traverse alternate beds of limestone and sandstone; and are very remarkable for their becoming suddenly thin and impoverished on passing from the limestone into the sandstone; and for resuming their richness, and usual size, on returning from the sandstone into the limestone. The exploitations are situated in the flanks of considerably high hills, bare of wood, and almost wholly covered with marshy heaths. The waters are drawn off by galleries of efflux; and the ores are dragged out by horses to the day. The galena extracted from these mines is smelted by means of coal and a little peat, in furnaces of the Scotch construction. The lead is very poor in silver; and there is hardly a single hearth for the purpose of eliminating this metal by cupellation. The mines of this district produce annually 17,200 tons of lead, according to Mr. Taylor's statement, published in the *Geology of England and Wales*, by Messrs. Conybeare and Phillips. There is moreover a copper mine 2 leagues S. W. of Alston-Moor. The ore is a copper pyrites, accompanied with galena in a very extensive vein, which does not appear to belong to the same formation as the other veins of this region.

The second metalliferous district lies in the northern part of Derbyshire, and in the counterminous parts of the neighbouring counties. The districts called the Peak and King's-Field are the richest in workable deposits. The mines of Derbyshire are getting exhausted; they are very numerous, but in general inconsiderable. The galena extracted from them is treated with coal in reverberatory furnaces; but the silver is not sought for. They yield annually 900 tons of lead; with a certain quantity of calamine, and a little copper ore. A vein of copper pyrites occurs at Ecton, in Staffordshire, on the borders of Derbyshire. The veins of Derbyshire are famous for the beautiful minerals which they have produced; and particularly for the interruption which they almost constantly suffer at the contact of the trap-rock, called toadstone, which is intruded among the limestone.

The third metalliferous district is situated in Flintshire and Denbighshire, counties forming the N. E. part of Wales. Next to Alston-Moor this is the most productive; furnishing annually 6,900 tons of lead, and a certain quantity of calamine. The galena is smelted in reverberatory furnaces, and affords a lead far from rich in silver, which is therefore seldom subjected to cupellation. The mines occur partly in the metalliferous limestone, and partly in several more ancient rocks.

To the S. E. of this district there exist still some lead mines in Shropshire. They

lie, like the preceding, partly in the metalliferous limestone, and partly in the subjacent rocks. They yield annually from 700 to 800 tons of lead.

Some mines of galena and calamine are mentioned in the Mendip hills, to the south of Bristol; but they seem to be for the present abandoned.

Besides the metallic mines just enumerated, the formation of the metalliferous limestone presents, in England, especially in the counties of Northumberland and Cumberland, several coal mines, opened on coal strata included by the sandstone, which alternates with the limestone.

MINES OF DAOURIA.

The name *Daouria* is given to a great region wholly mountainous, which extends from the Baikal Lake to the Eastern Ocean. There is, perhaps, no other country in the world so rich in deposits of lead ores, as the part of this district which extends from the junction of the rivers *Chilca* and *Argoun*, whose united waters form the river *Amour*, belonging to Russia. The mines opened here constitute the third arrondissement of the Siberian mines, called that of *Nertchinsk*, from the name of its capital, which lies more than 1800 leagues east of Saint Petersburg.

The ground of the metalliferous portion of *Daouria* is formed of granite, hornschiefer, and schists, on which reposes a gray limestone, sometimes siliceous and argillaceous, which contains a small number of fossils, and in which the veins of lead occur. The plains of these regions, often salt deserts, exhibit remarkable sandstones and pudding-stones; as also vesicular rocks of a volcanic aspect. It appears that the metalliferous limestone is much dislocated, and the lead veins are subject to several irregularities, which render their exploitation difficult and uncertain. The mines lie chiefly near the banks of the *Chilca* and the *Argoun*, in several cantons, at a considerable distance from one another; wherefore it was requisite to build a great number of smelting furnaces. The want of wood has placed difficulties in the working of some of them. The ore is galena, sometimes occurring in masses of several yards in diameter; having commonly for vein-stones ores of iron and zinc, of which no use is made. The galena itself, furnished by these mines in enormous quantities, receives a very different treatment from what it would do in a civilized country; for, though the lead which it produces contains only from 6 to 10 gros (1 to 1½ ounce) of silver per quintal, it is for it alone that these mines are worked. The litharge produced by the cupellation is thrown away as useless; so that heaps of it exist near the smelting-furnaces, says *M. Patrin*, higher than the houses. Only an insignificant quantity of it is reduced to lead for the uses of the country, or for those of the foundries in the arrondissement of *Kolywan*. The silver extracted from the mines of *Daouria*, contains a very small proportion of gold. *M. Patrin* says that their annual product was, towards the year 1784, from 30 to 35 thousand marcs of silver. The exploitation of some of the mines of *Daouria* goes back to the end of the 17th century. It had been commenced in some points by the Chinese, who were not entirely expelled from this territory till the beginning of the following century. A great part of the mines, however, has been opened up since 1760.

Besides the lead mines, there are some unimportant mines of copper in *Daouria*, and in different explorations of this region, arsenical pyrites, from which arsenious acid is sublimed in factories established at *Jutlack* and at *Tchalbutchinsky*.

About 45 leagues to the south of *Nertchinsk*, the mountain of *Odon-Tchelon* occurs, celebrated for the different gems or precious stones extracted from it. It is formed of a friable granite, including harder nodules or balls which inclose topazes; it is very analogous to the topaz rock of Saxony. In this granite there are several veins filled with a ferruginous clay, which contains a great quantity of wolfram, and many emeralds, aqua marines, topazes, crystals of smoked quartz, &c. Multitudes of these minerals have been extracted by means of some very irregular workings. The mountain of *Toutt-Kaltoui*, situated near the preceding, offers analogous deposits. The presence of wolfram had excited hopes that tin might be found in these mountains; hopes which have not hitherto been realized. There are some unworked deposits of sulphuret of antimony in this country.

ON SOME OTHER LESS KNOWN MINE COUNTRIES.

There seem to exist in Brazil, besides the washings of the sands that produce the diamonds, the precious stones, the platinum, and almost all the gold of this country, some mines of gold, lead, and iron, opened up in very ancient geological formations; but there is no silver mine, which indicates a great difference between the metalliferous deposits of this district and those of Spanish America. The lead mines occur particularly in the captainry of *Minas-Geraes*, canton of *Abaité*. Their exploitation has been undertaken within a few years. The captainry of *Minas-Geraes* contains extremely abundant deposits of black oxide of iron, and specular iron, which constitute beds or enormous masses, forming sometimes entire mountains; along with numerous

veins of hematite and red oxide of iron. Lately these have been opened up, and smelting-houses have been established at Gaspar-Saarez. There are also iron mines and foundries in the captainry of Saint-Paul. A mine of antimony occurs near Sabara, in the captainry of Minas-Geraes.

In Africa, the inhabitants of the countries adjoining to the cape of Good Hope mine and smelt copper and iron; and the Congo produces considerable quantities of these two metals. It is asserted that a great deal of copper exists in Abyssinia. On the banks of the Senegal, the Moors and the Pouls fabricate iron in travelling forges. They employ as the ore the richest portions of a ferruginous sandstone, which seems to be a very modern formation. Lastly, the kingdoms of Morocco and Barbary appear to include several copper and iron mines.

The islands of Cyprus and Negropont, in the Mediterranean, were celebrated, in former times, for their copper mines; and several islands of the Archipelago presented gold mines, now abandoned. The same thing may be said of Macedonia and Thrace. The mountains of Servia and Albania contain iron mines; and lead mines occur in Servia. Natolia possesses iron and copper mines in the neighbourhood of Tokat. Some also occur in Arabia and in Persia; and in the territories round Caucasus, the kingdom of Imeretta is distinguished for its iron mines. The celebrity of the Damascus sabres attests the good quality of the products of some of the mines. Persia includes, besides, mines of argentiferous lead at *Kervan*, a few leagues from Ispahan; and Natolia furnishes orpiment.

Some iron and copper mines have been mentioned in Tartary. Thibet passes for being rich in gold and silver mines. China produces a great quantity of iron and mercury, as well as white brass (*tombac*), which is much admired. The copper mines of this empire lie principally in the province of Yu Nan and the island Formosa. Japan, likewise, possesses copper mines in the provinces of Kijunack and Sarunga. They seem to be abundant; at a period not far back, they exported their products to Europe. Japan presents, moreover, mines of quicksilver. China and Japan contain also mines of gold, silver, tin, red sulphuret of arsenic, &c. Large deposits of the latter ore (realgar) are said to occur in the tin mine of Kian-Fu in China. But in that empire, as in Europe, coal is the most important of the mining products. This combustible is explored, especially in the environs of Peking, and in the northern parts of the empire.

Iron mines exist in several points of the Burman empire, and of Hindostan. Near Madras, there exist excellent ores of sparry iron, and black oxide, analogous to the Swedish ores. The Indian natural steel, named Wootz, has been held in considerable estimation among some eminent London cutlers; but the iron and steel recently manufactured upon a great scale near Madras, by Messrs. Heath and Co., from the crystallized magnetic ore of that country, will probably ere long rival, and eventually supersede in Europe the product of the Dannemara forges. The islands of Macassar, Borneo and Timor, include copper mines. As to the tin obtained from the island of Banca, from the peninsula of Malacca, and several other points of southern Asia, it proceeds entirely from the washing of sands. The same is undoubtedly true of the gold furnished by the Philippine isles, Borneo, &c. It appears, however, that mines of gold and silver are worked in the island of Sumatra.

MINES OF THE SECONDARY ROCK FORMATIONS.

The most important mines of the secondary rocks, and perhaps of all minerals whatsoever, are those worked in the most ancient of these strata, in the coal-measures.

The British Islands, France, and Germany present several groups of small mountains primitive on the ridge, and transition on the flanks; in the sinuosities between which deposits of coal occur. The principal of these have become great centres of manufactures; for Glasgow, Newcastle, Sheffield, Birmingham, Saint-Etienne, &c., owe their prosperity and their rapid enlargement to the coal, raised, as it were, at their gates in enormous quantities. Wales, Flanders, Silesia, and the adjacent parts of Galicia, owe equally to their extensive collieries a great portion of their activity, their wealth, and their population. Other coal districts, less rich, or mined on a less extended scale, have procured for their inhabitants less distinguished, but by no means inconsiderable, advantages; such, for examples in Great Britain, are Derbyshire, Cheshire, Lancashire, Shropshire, Warwickshire, the environs of Bristol, &c.; some parts of Ireland; in France, Litry department of Calvados, Comanterie, Saint-Georges-Chatelaison, Aubin, Alais, le Creusot; Ronchamp, in the Prussian provinces of the left bank of the Rhine; the environs of Saarebrück; several points of the north of the territory of Berg and Lamerck, of Mansfeld, of Saxony, Hungary, Spain, Portugal, the United States, &c.

We need not enter here into ampler details on coal mines, reserving these particulars for the article *PIRICAL*.

Nature has deposited alongside of coal an ore, whose intrinsic value alone is very small, but whose abundance in the neighbourhood of fuel becomes extremely precious to

man; we allude to the clay-ironstone of the coal-measures. It is extracted in enormous quantities from the coal-basins of Scotland, Yorkshire, Staffordshire, Shropshire, and South Wales.

Much of it is also raised from the coal strata of Silesia; and the French entertain hopes of finding a supply of this necessary ore in their own country. The iron-works of England, which are supplied almost entirely from this iron-stone reduced with the coke or coal, pour annually into commerce more than one million tons of cast and bar iron, the value of which has been estimated at eight millions sterling; an amount fully equal to the product of all the mines of Spanish America.

The shale or slate-clay of the coal-measures contains sometimes a very large quantity of pyrites, which, decomposing by the action of air, with or without artificial heat, produces sulphate of iron and sulphate of alumina; whence coppers and alum are manufactured in great abundance.

The lead mines of Bleyberg and Gemünd, near Aix-la-Chapelle, are explored in a sandstone referred by many geologists to the red sandstone. The ore consists principally of nodules of galena disseminated in this rock. They are very abundant, and of very easy exploration. These mines produce annually from 700 to 800 tons of lead, which does not contain silver in sufficient proportion to be worth the extracting. 2000 tons of ore are prepared and sold in the form of black lead dust (*alquifous*).

The manganese mines worked in the open air near Excter in England, occur in a sandstone analogous to the red.

The calcareous formation which surmounts the coal-sandstone, called by geologists *zechstein*, magnesian limestone, and older Alpine limestone, contains different deposits of metallic ores; the most celebrated being the cupreous schist of Mansfeldt, a stratum of calcareous slate from a few inches to two feet thick, containing copper pyrites in sufficient quantity to afford 2 per cent. of the weight of the ore of an argentiferous copper. This thin layer displays itself in the north of Germany over a length of eighty leagues, from the coast of the Elbe to the banks of the Rhine. Notwithstanding its thinness and relative poverty, skilful miners have contrived to establish, on different points of this slate, a number of important explorations, the most considerable being in the territory of Mansfeldt, particularly near Rottenburg. They produce annually 2000 tons of copper, and 20,000 marcs of silver. We may also mention those of Hessa, situated near Frankenberg, Bieber, and Riegelsdorf. In the latter, the cupreous schist and its accompanying strata, are traversed by veins of cobalt, mined by the same system of underground workings as the schist. These operations are considerable; they extend, in the direction of the strata, through a length of 8700 yards, and penetrate downwards to a very great depth. Three galleries of efflux are to be observed; two of which pour their waters into the Fulde, and the third into the Verra. One of them runs about 20 yards below the most elevated point of the workings. These mines have been in activity since the year 1530. Analogous mines exist near Sealfeld in Saxony.

To the same geological formation must probably be referred the limestone which contains the sparry iron mine of Schmalcalden at the western foot of Thuringerwald, where there has been explored from time immemorial a considerable mass of this ore known by the name of *Stahlberg*. The working is executed in the most irregular manner, and has opened up enormous excavations; whence disastrous ruins have taken place in the mines. It furnishes annually 4500 tons of ore, which keep in play a great number of furnaces, where a deal of iron and steel is manufactured.

At Tarnowitz, 14 leagues S. E. of Oppeln in Siberia, the *zechstein* contains, in some of its strata, considerable quantities of galena and calamine; into which, mines have been opened, that yield annually from 600 to 700 tons of lead, 1000 to 1100 marcs of silver, and much calamine. Mines of argentiferous lead are noticed at Olkutch and Jaworno in Galicia, about 6 leagues N. E. of Cracow, and 15 leagues E. N. E. of Tarnowitz. Their position seems to indicate that they belong to the same formation; and possibly those of Willach and Bleyberg in Carinthia have the same locality.

There has been discovered lately near *Comfolens* in the department of *la Charente*, in a secondary limestone, calcareous beds, and particularly subordinate beds of quartz, which contain considerable quantities of galena. At *Figeac* also, in the department of *le Lot*, deposits of galena, blende, and calamine occur in a secondary limestone. At *la Voulte* on the banks of the Rhone, there is mined, in the lower courses of the limestones that constitute a great portion of the department of the Ardèche, a powerful bed of iron ore.

It is in the *zechstein*, or in the sandstones, and trap rocks of nearly the same age, that the four great deposits of the sulphuret of mercury, of *Idria*, the *Palatinat*, *Almaden*, and *Huancavelica*, are mined.

The formation which separates the *zechstein* from the lias (*calcaire a gryphites*), called new red sandstone and red marl in England, and *bunter-sandstein*, *muschelkalk*, and *quadersandstein* in Germany, presents hardly any important mines except those of rock

salt; which enrich it, not only in the centre of Europe, as in Cheshire, at Vic, Wieliczka, Bochnia, and Salsbourg, but in many other parts of the world.

The lias contains often very pyritous lignites, which are mined in many places, and particularly at Whitby and Guisborough in Yorkshire, for the manufacture of alum and copperas.

The oolitic limestone contain strata of iron ore, which are mined in some districts of France.

The iron sand (Hastings sand) beneath the chalk formation, is often so strongly imbued with iron as to be worth the working.

The lowest beds of the chalk contain iron pyrites, which has become the object of an important exploration at *Vissans* on the southern coast of the *Pas-de-Calais*, where it is converted into sulphate of iron. The waves turn the nodules out of their bed, and roll them on the shore, where they are picked up.

If the chalk be poor in useful minerals, this is not the case with the plastic clay formation above it; for it contains important mines. In it are explored numerous beds of lignite (wood-coal), either as fuel or a vitriolic earth. From these lignite deposits, also, the yellow amber is extracted.

The other tertiary formations present merely a few mines of iron and bitumen.

Several of the secondary or tertiary strata contain deposits of sulphur, which are mined in various countries.

The formations of a decidedly volcanic origin afford few mining materials, if we except sulphur, alum, and opals.

MINES OF THE ALLUVIAL STRATA.

This formation contains very important mines, since from it are extracted all the diamonds, and almost all the precious stones, the platinum, and the greatest part of the gold, with a considerable portion of the tin and iron. The diamond mines are confined nearly to Brazil, and to the kingdoms of Golconda and Visapour in the East Indies.

MINES, VENTILATION OF. The means adopted in the South Staffordshire coal mines, which have veins varying from 25 to 30 feet in thickness, are well worthy of consideration; since a solid mass of that magnitude must be peculiarly difficult to drain of its imprisoned gas. In excavating such coal large masses must be detached, and pockets or hollows must be formed, which are immediately filled with carburetted hydrogen; whilst a thin vein, for which a level roof can be generally secured, can be kept tolerably free from such accumulations.

In December, 1846, in consequence of a frightful explosion which took place at Oldbury, Mr. Benjamin Gibbons was induced to publish a small work descriptive of the principles of ventilation adopted and practised by him for many years before in the thick and thin mines that were worked under his personal superintendence.

The author first recapitulates the substance of a part of his work, and gives, in addition, the results of an enlarged experience, as well as a slight notice and reply to some of the objections made to his plan.

Carburetted hydrogen gas, which produces these dreadful explosions, is not explosive until it is united with a certain proportion of ordinary air, say seven to nine times its volume; when this mixture has taken place, it arrives at what is termed its "firing" or explosive point; and in that state, if it come in contact with the flame of a candle, it will instantly explode, with similar rapidity and violence to gunpowder. A considerable volume of this gas is set at liberty in all the thick coal mines, when worked in the usual manner, and as often as fresh masses of coal are cut through. Some coal mines supply a much greater quantity of gas than others; and these are commonly called "fiery mines;" but, in all coal mines, a sufficient quantity is extricated to produce the most direful consequences, if it be not neutralized, or its escape duly provided for.

The general mode is that of diluting the gas with a quantity of atmospheric air; and a current of air, equal to thirty times the volume of gas yielded by the coal, is, in the author's opinion, the bare limit of safety: that is to say, thirty cubic feet of common air must circulate through the mine in the space of time that the coal will give out one cubic foot of gas; but the quantity of air should exceed this, where this mode of ventilation is practised; for a copious supply of fresh air is needful for the numerous workmen, horses, and candles, employed in the pit.

Many mechanical plans have been recommended to increase the current of air through the mines; in some, force pumps, and in others, exhaust pumps, have been proposed, to produce an artificial current of air throughout the workings. These plans, theoretically, may be very correct, but, it is to be observed, that the current of air must be constantly maintained; and, in the practical application, the engine that works these pumps, or other mechanical means, may get out of order, and thereby endanger the lives of all the miners. This fatal objection attaches to all mechanical plans of ventilation; and, indeed, to all artificial modes, where the power of ventilation is not self-acting, —

but requires the constant action of machinery, or the constant aid of men; even including the ordinary plan of rarefaction of the air by a separate fire, which may be out when it ought to be in, and ought not to be relied upon as the sole protector, though it will be, in some circumstances, a useful auxiliary.

We should therefore avail ourselves, as far as possible, of the natural powers that are at our command; and, in this instance, the extreme levity of the gas from which we wish to rid the mines, supplies us, to a considerable extent, with the remedy required. But cases may arise where other auxiliaries may be temporarily required, from accidental misplacements of the level of the mine; although, in the author's opinion, these cases may be reduced to a few, if the mines are opened out and worked upon a proper system, as will be further noticed in this paper. Under these circumstances, it may be necessary to employ heat, to rarefy the upcast current of air, to make it specifically lighter than the downcast; or mechanical means to force air in, or to extract air from the mines, may be required. Where artificial heat is made use of a steam-jet, from the boiler of the winding engine, is the most secure method; because, the steam being supplied from the boiler of the winding-engine, it is clear that the steam is always at command whilst the pit is at work. If mechanical means should become necessary, Mr. Struve's exhausting cylinders supply the most powerful and effective apparatus that has fallen under the author's notice.

The object of the present paper is to show that there is a constant self-acting power available, which experience has shown will afford the desired protection in ordinary temperatures, in the majority of cases; because the carburetted hydrogen of the mines being half the weight of common air (it has an equal ascending power to common air heated to 512°, being of the same specific gravity), will rise to the highest parts of the mine, and would escape with great velocity, if permitted to do so; forming, in the aggregate, a very large ascending power, as exemplified in the balloon; but, in the ordinary system of working, this escape is unprovided for, indeed, absolutely prevented.

According to the ordinary system adopted in the collieries of this district, two shafts are sunk, near together, about 7 to 7½ feet in diameter, each to the bottom of the coal, say about 180 yards depth, the two shafts commencing at the same level, and terminating at the same level. One of these becomes the "downcast pit" down which the air descends, and the other the "upcast pit" up which the air ascends, when a communication is made between them at the bottom; but the only determining causes for the motion of the air being accidental, it is unknown beforehand what direction the current will take, and which will become the downcast pit. It is generally found that a current of air does take place, (it may almost be said always takes place), without any other means being employed; but the determining power is so faint, that, issuing from the upcast pit with such trifling velocity, it is liable to be deranged by the action of the wind, or by atmospheric changes; and it sometimes happens that the air becomes quiescent, or an unsteady column, alternately ascending and descending the same shaft; and then, in miner's language, the pits "fight," and the air will neither ascend nor descend with regularity in one direction. But worst of all, the course of the air will be sometimes inverted or "turned" — that which should be the downcast pit becoming the upcast; and the mine then becomes exposed to the most fearful results, where the workings have been opened, by the air being driven backwards along the air-head into the reservoirs of gas formed in the upper cavities of the workings, and issuing into the gate-road, charging the gas to the firing point.

The danger of this change in the direction of the air current is increased by the upcast pit being used as a working shaft. The upcast pit (which is, in fact, the main gas and air-way, and which ought always to be closed from the external air, and the ascending air current guarded from disturbance or commotion, to prevent the slightest interruption to the current of air upon which the lives of all depend) is kept in a state of constant agitation by the ascent and descent of the "skips," loaded with coal, which nearly fill the shaft. To crown this, when every skip arrives at the top of the shaft, a carriage, boarded over, called the "runner," is wheeled over the mouth of the pit whilst the coal is landed, and then withdrawn to allow the skip to descend. It is obvious that the air, which should never be disturbed, is thus constantly liable to be in conflicting currents, more or less, sometimes upwards and sometimes downwards; and whenever the mouth of the shaft is covered by the runner, the air is in a state of partial stagnation. But it sometimes occurs that the chain or tackle, by which the skip is suspended, breaks during the ascent in the upcast shaft; the skip then drops down the shaft, drives the air before it with great velocity along the air-head, and forces the gas out of the cavities into the workings, down upon the candles of the workmen; and this the author has known to happen many times.

When the two pits are sunk down through the stratum of coal 30 ft. in thickness, a "gate-road" or horse-way is next driven in the bottom of the coal, from 8 to 9 ft. high, and about the same width, commencing from the bottom of the downcast pit.

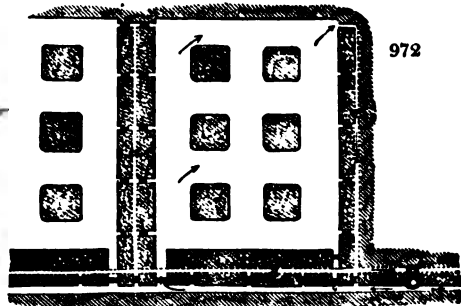
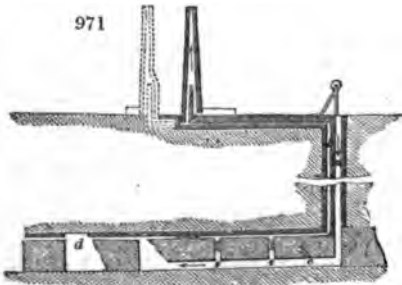
At the same time, (or rather before, as it should always precede the gate road) an air-head is driven about the middle of the coal, or 15 ft. high from the "floor" or bottom of the coal, commencing from the downcast pit. The gate-road and air-head are then driven in parallel lines, at the same level upon which they commence, for the distance of 100 to 500 yards, or more, according to the quantity of coal intended to be cleared by the pits.

A series of "spouts" or openings are driven upwards from the gate-road into the air-head, at intervals of 10 or 15 yards, (as the coal may give out more or less gas) to carry off the gas, and produce a current of air for the workmen,—each spout being closed up when a new one is made in advance. The excavation of the whole thickness of the stratum of coal, 30 ft. thick, is then proceeded with, by opening right and left from the end of the gate-road, and excavating a "side of work," which forms a rectangular cavity, say about 90 yards long by 50 yards wide, or about an acre, the whole of the coal being taken away as far as practicable, excepting the pillars of coal (generally 10 yards square and 10 yards distant from each other) which are left to support the superincumbent strata.

The air descending the downcast pit, and travelling along the gate-road into the workings, ascends to the air-head, and, traversing that, ascends the upcast pit, carrying with it the gas and impure vapours, as far as such imperfect and interrupted means will effect, and delivering them into the open air.

By this plan we may contrive (where this system is adopted) to ventilate the mine, though imperfectly, until the lower 15 feet of the coal is excavated; but where the whole thickness of the coal above the air-head has been removed, by undergoing the coal from the bottom, and dropping it down in large masses, the upper portion of the cavity, being above the level of the air-head, forms a reservoir for gas, which gradually accumulates, and has no means of escape,—a reservoir of the capacity of some hundred thousand of cubic feet, which may be wholly or in part occupied by gas. An accidental change in the direction of the current of air would turn the course of the air along the air-head into this reservoir of gas, and from thence into the gate-road, and render an explosion very probable. After the coal is extracted, a solid wall or "rib" of coal, from 6 to 10 yards thick, which is commonly termed a "fire-rib," is left all round the chamber, separating it from the next workings; and the entrance from the gate-road is securely walled up, to exclude the air, and prevent spontaneous combustion, which would otherwise, in a short period, take place. When an explosion occurs, it is generally followed by a second, or more, as portions of the gas become successively charged with the due proportions of air; and the liability to these terrible explosions will always remain in mines thus worked, till, by some efficient means, the gas can be allowed a continuous escape, and a current of air can be ensured to move always in one direction, with sufficient power to overcome all extraneous disturbing forces, either of the wind or any atmospheric changes.

In *Fig. 971.* the system adopted and carried into operation by the author is shown. One pit *a*, is sunk, instead of two; and in the side of the shaft a smaller shaft *b* is cut, to form an "air chimney," and is afterwards separated from the main shaft; this air chimney is circular, and may be made about 3 feet diameter inside, or more, as may be required. The air-chimney is bricked at the same time with the shaft,—the circular brickwork of each forming a partition of double thickness and secure strength, from the two arches abutting against each other.



The gate-road *c*, is driven from the shaft at the bottom of the coal, as in the ordinary plan; but the air-head *d* is driven from the air chimney within 2 feet of the top of the coal, or higher if practicable, and runs into the vertical air chimney. The gate-road and air-head are carried forward in a parallel direction to the extent of the work,

as before described in the ordinary system; and "spouts" or openings, *e*, are driven upwards to connect them, at about every 15 yards—every spout being bricked up close, in succession, when a fresh one is made in advance, so as to make the current of air traverse the whole extent of the gate-road before it rises up to the air-head and passes away to the air chimney. These spouts can only be driven perpendicularly upwards from the gate-road to the air-head; and each of them being about 18 feet long in the 30 feet coal, a formidable practical difficulty was experienced by the author in the King Swinford pits, where the coal being contiguous to a great fault, it abounded in gas to so great a degree, that when a spout was carried up a very few feet, it became so filled with gas that no man could work in it. But this difficulty was overcome by boring upwards from the spout a hole, 4 inches in diameter, into the air-head; the gas then passed off instantly, followed by a stream of air sufficient to ventilate the gate-road, and to enable the men to work with candles in the spout with perfect safety.

The excavation of the coal is commenced in the same manner as in the ordinary system, by driving at right angles from the end of the gate-road, to begin a "side of work;" and the ventilation is carried on completely and continuously from the extremity of the working, whilst the whole of the coal to the top is removed. The whole of the gas is constantly drained off from the upper surface of the coal by the air-head, and the numerous spouts or cross drains, which remain all open to the air-head, by means of a small pipe-hole left in the stopping as they are successively stopped, and which constantly drain off the gas most effectually, by piercing through and cutting the horizontal layers of coal, and thus tapping the several strata at so many different points. By this system the danger of any accumulation of gas in the cavities of the upper part of the workings is effectually prevented.

In the ordinary system of ventilation, it is manifest that only a very slight determining power compels the air to travel constantly in the same direction. Its current is, at all times, weak and insufficient, and liable to be deranged by the action of the wind, or atmospheric changes; and it is under no command whatever. To ensure safety, a constant current of air is indispensably necessary; it should be a current, too, maintained by natural causes, as far as possible, and never interrupted, for the reasons already assigned; and should be one that would not vary or fail.

To effect this, the ascending column of air must be rendered specifically lighter than the air of the descending column, which circulates through the workings; and this difference of specific gravity must be maintained constantly free from disturbance, by accidental causes, and, to such an extent, as to produce, under all circumstances, a total amount of propelling power that is found sufficient for the complete ventilation of the mine. This is accomplished by conducting the whole of the gas in a continuous ascending column, free from interruption or disturbance, up the separate air-chimney; and this ascending power is further increased by erecting a ventilating chimney (shown by dots, in the vertical section), of a sufficient height, on the surface of the ground, into the base of which the air-chimney is continued so as to form one uninterrupted air flue, from the top of the ventilating chimney, down to the air-head in the seam of coal. By this means, a long experience has shown that a constant draught is established and secured, with the occasional aids of a small furnace or steam jet, which is amply sufficient, in all ordinary cases, to defy wind and weather, and also to produce a current sufficiently strong, that it may be split, and such portions withdrawn from the main stream of air as may be found requisite to carry on the preparatory work to maintain the get of coal.

The air in the gate-road and workings is warmed above the temperature of the air on the surface, in ordinary mean temperatures, by the heat of the earth, and is consequently rarefied; this is aided much more than would be generally supposed, by the heat proceeding from the numerous workmen, horses, and candles, employed in the mine; and the current is further increased by the escape of the gases, which are specifically lighter than the air,—the air-head forming, with the air-chimney, an uninterrupted and continuous passage from the workings, and delivering the gas into the ventilating chimney: thus a draught is constantly maintained sufficient for all usual purposes. The weak power of draught that exists in the old system is materially diminished by the upcast shaft being of a larger size than the air-head through which the downward current of air must pass. The ascending current, in consequence, is languid and slow; whereas, in the author's judgment, it should have considerable velocity; and much more important advantages arise from this cause than philosophers account for or will admit.

Cases may occur in which it is desirable, for temporary purposes, to increase the draught, either when the external air is at a very high temperature, or from other causes; and this is at once obtained by adding a furnace, or a steam jet, of any required power, to the ventilating chimney. By means of a fire in this furnace, any degree of rarefaction may be produced that is desired in the ventilating chimney; and it is recommended always to build one where the boiler chimney cannot be used, that it may be used if it is wanted. In such cases, the flue of the furnace should be carried up perpendicularly, for 30 or 40 feet, against the side of the ventilating chimney, before it is

opened into it. This precaution will render a deflagration of the gases, passing up the chimney, impossible, when the furnace is used.

The principle of ventilating pits by an air-chimney used for no other purpose than the passage of the gas and the current of air from the workings to the surface, has been adopted by the author, in a more or less perfect form, for more than 30 years, in working the thick and thin mines, and has been found to give a complete and absolute command over the ventilation of every part of the mines. It is only, however, within the last few years, that he has had an opportunity of carrying it through many extensive pits systematically. In the whole of the author's mines, this system of ventilation is now completely carried on. The thick coal is sometimes worked in one pit, and in another pit, brooch coal, heathen coal, or the white iron stone lying beneath the coal; and sometimes the thick coal is worked in both. Very little preparation is necessary for this change from one to the other, as the air-chimney reaches to the lowest vein; and, a stopping being put in at the level of the vein intended to be got, a supply of air may be immediately procured at any required level. The thick coal abounded in gas in these pits; but it is now so drained, that all difficulties have disappeared. The use of the safety lamp has become a form rather than an essential.

A great improvement is perceptible in the health and comfort of the workmen employed. The air in these pits is always free from gas, and is 10° Fahr. cooler than the neighbouring pits, worked on the ordinary system, owing to the regular supply of fresh air. They have been frequently tried, and found to be 62° or 64° in the workings; whilst, at the same time, the air in the working of pits ventilated in the ordinary way was found, in many cases, to be 72° to 74° : the former, the temperature of a comfortable sitting room, and the latter, that of a heated cotton-mill.

A great saving of expense from this system will be found also, not only in working the thick coal, but, subsequently, in getting the thinner veins of coal and ironstone. A considerable amount of outlay, as well as frequently a great loss of time, is incurred in obtaining the necessary supplies of air for working the successive strata of a mine. Whereas, the air-chimney is accessible at any point in the shaft; and the shaft is always kept well aired, which is of importance, as it is always found convenient to suspend the workings of the pit for a considerable time after the partial exhaustion of one of the strata, and before it may be desirable to commence the working of another.

It may be observed here, that an air-chimney may be very easily cut down any shaft that has been sunk in the usual way. The author has cut one down a shaft during the night, whilst the pit continued to draw coal during the day. He executed one in a pit, 140 yards deep, in about a month,—the pit continuing to draw coal during the day, whilst the air-chimney was made during the night.

Where large quantities of coal are to be drawn, a number of shafts are necessary. Two of these may be sunk at the usual distance 10 or 12 yards, near enough to be commanded by the same winding engine, but the shafts having no communication with each other. But if the form of the mine makes it more convenient, they may be sunk singly in any required situation; because each separate shaft will provide its own air, and each shaft will "get" the separate section of mine appropriated to it. By this means, small detached portions of mine have been got to advantage, that would not have paid for the expense of two shafts.

By this arrangement, a smaller quantity of air-heading is required to "get" the same area of coal; and the process of complete ventilation can be more easily carried out, as will be hereafter noticed; and, as communications between different shafts, by the gate-roads, might be occasionally convenient, these communications may be under the care and sole control of the mine director, who may keep the doors locked, if advisable: the ventilation is thus not materially disturbed.

In the different plans for ventilating mines, the merit appears to have been awarded to those more especially who have succeeded in forcing by any means, either mechanical, or by the use of powerful furnaces, the largest possible quantity of air through the workings in a given time. The principle explained in the present paper is totally different, and diametrically opposite; for it consists in draining the gas away from the coal before it is worked, and then getting the coal when it is thus drained, and carrying no more air through the mines than is required for light, life, and health.

Thus, to illustrate the difference between the two principles of ventilation, supposing that 1,000 cubic feet of gas per minute is emitted by the coal, and passed through the workings, 35,000 cubic feet of air per minute must, according to the old method, be passed through the mine,—that is 30,000 feet to dilute the gas, and 5,000 feet to supply the workmen, horses, and candles, in the workings; but, if the whole of this 1000 feet of gas can be carried off by its own levity and intercepted from passing into the workings, then the mine will be better and more safely ventilated by 5000 feet of air per minute than by 25,000 feet in the former case; or, if the whole of the gas cannot be intercepted, then in such proportion as the volume of gas can be intercepted and carried away. And

supposing the opinion of the author to be correct, that the gas can be carried away without passing into the workings, and that, therefore, a very greatly reduced quantity of air is necessary in the mine, it follows that (the gas being of the same specific gravity as atmospheric air, heated up to 512°) when the gas becomes diffused and united with the air, the volume of air and gas, so united, is of less specific gravity than the air, and will maintain a natural ventilation of considerable power. It may be observed also, that very rapid currents of air through the passages of a mine are always attended with great inconvenience to the workman, and may be attended with great practical danger, from the circumstance, that the union or perfect admixture of the carburetted hydrogen with atmospheric air, though very rapid, is not instantaneous; and when in a mine not previously drained of its gas, large quantities of the gas, suddenly escaping from powerful "blowers," are driven forwards by a current of air, moving from 7 to 10 feet per second, it is very conceivable that they are not diffused at once, but carried, in some degree, like a cloud of steam, forwards through the mine, till diffusion has brought a portion to the "firing point:" this, meeting with a light, or being driven, as is possible, through the wire of the safety lamp, will inevitably cause an explosion.

An objection that was made to the adoption of the system was, the possibility of some disturbance of the brickwork, which separated the air-chimney from the main shaft, either by a violent blow from the ascending skip (which, of course, could not be the case with the guides that are now generally used), or by any accidental explosion that might take place in the mine, which, it was contended, might force it outwards into the main shaft. A mere inspection of the plan must convince any practical person that such an occurrence is impossible. Any force from without would be resisted by the convex surface of the arch which encloses the small shaft, as any operating from within would be as effectually resisted by the convex surface of the main shaft. Not only did no such occurrence ever take place in the numerous pits where the plan has been used without guides; but even where the air-chimney was cut square, possessing so much less resisting power, it remains now perfect and uninjured after a lapse of more than thirty years.

Another objection was, that the air-chimney was not of sufficient dimensions to ventilate the mine; and this objection was urged and re-urged in the face of the fact, that the author had expressly stated that cases might occur, where even a seven foot air-shaft might be required and employed to drain very fiery mines. The parties making this objection did not happen to recollect that, in fact, this air-chimney was precisely of the same area as the air-head, which they themselves always employed, to form the communication between the workings and the upcast shaft. That, in fact, the air-chimney was nothing more nor less than a continuation of the air-head from the workings to the surface of the ground; and consequently, the effect of enlarging the air-chimney would be to diminish the velocity of the ascending column, and to lose the increased temperature the air had acquired in passing through the mine.

Another objection was, that in some of the thinner veins no upper air-head could be driven at a sufficient height to allow the gas to escape by its own levity, or to prevent it from getting admission to the workings. There may be exceptional cases; as, for example, if a mine can be supposed to lie upon a perfectly horizontal plane (but the author never saw an instance of a mine to any considerable extent answering this description; in all mines he has ever seen, the coal forms some angle to the horizon in some direction; and a very small angle will soon obtain a height of 6 or 7 feet, which is quite sufficient for the present purpose): in that case the air-head, communicating to the upcast shaft, may be made always to descend to the higher part of the plane, which will be quite sufficient to keep the mine clear from gas, by allowing it to pass off by its own levity. But, even if such a case ever should occur, a remedy may often be obtained, an instance of which has lately occurred to the author. A disturbance in the thick coal vein was found, breaking the coal through and throwing it into a trough 15 yards below its level: of course if the air-head had continued to follow the vein, it must have been depressed below its level to an extent equal to the whole thickness of the coal, which would have formed a barrier against the passage of the gas, like an inverted syphon, which the gas would not have passed. The remedy adopted by the author was, by commencing an air-head from the air-chimney in another measure, the "flying-red," that lay 20 yards above the main coal, and continuing it till it had passed over the depressed point; a communication was then formed to the upper side of this depressed point, which at once established a rising air-head for the whole of the coal on the further side of the depression.

It may be perceived that the plan of ventilation here recommended is combined, in some measure, with the method of working the mines, and may be made more perfect and efficient by the adoption of a sound system. The common mode is that of working the mines in "panes," or "panels," leaving pillars or portions of coal to be extracted at a future period; but this is considered by the author as highly objectionable.

The danger of this method must be sufficiently obvious, when it is seen that the air

must be forced through the most crooked and winding channels, and compelled to pass along by artificial buildings, or "brattices," the accidental destruction or failure of which may suspend the whole ventilation.

But the plan exhibited will show that before any coal is got from the mine, in the method recommended by the author, the roads are carried out to the extreme extent that the coal is proposed to be worked, accompanied by their air-heads: by this means the complete drainage of the gas from the mass of coal proposed to be worked is effected; and these roads and their air-heads are originally made at infinitely less expense, and are always in a safe and secure state, as the excavations commence at the outside of the coal thus intended to be got; and no brattices are necessary, as double doors may be used in any of these roads down which the air is intended to circulate, either to regulate the quantity, or prevent its passage; and the current of air may be always brought to act directly upon the working face of the coal.

It may be objected, that these pillars must be left for a support, owing to the nature of the roof of the mine; but this the author has never yet seen, and is disposed to think it never can happen. He is getting veins of coal of 90 feet in thickness, (in two successive workings of 15 feet each), also veins of 6 feet, 4 feet, and 3 feet thicknesses. The roofs of these various coals differ in their tenacity, and some of them are extremely tender, and yet the whole of the coal is extracted from these veins, both the thickest and the thinnest, both large and small coal, with the greatest facility and safety.

The dangers obviated by this mode of working are doubly important; the roof gradually descends as the mine is excavated; all dangers are left behind; and the roof is consolidated into a compact mass by the weight of the superincumbent strata: consequently no "gouf," or hollow, is ever formed, and no lodgment of gas can take place. Secondly, no large or small coal being left behind, the heating of the gouf, or the spontaneous combustion to which all mines are liable where small coal or slack is left, can never take place.

In working mines in panes and pillars, (where a part of the coal is left and eventually lost, the difficulty of obtaining safe ventilation will be understood from the following remark. At Newcastle-on-Tyne, the brattices have been all blown down by an explosion, and the workings filled with carbonic acid gas, and no means existing of quickly restoring the ventilation (as at the Felling Colliery), the pits and workings could not be entered, nor the bodies of the men recovered, for weeks, nay, even months. Every man in the mine, though out of the reach of the explosion, necessarily lost his life by the after-damp. A very recent case in Scotland, at Nitshill, where 69 lives were lost, is a striking example; although this pit had a good and distinct upcast shaft, the brattices were destroyed, the air of course proceeded along the shortest and most direct road from the downcast to the upcast shaft, and all the men who had been supplied with air by the diversion of the currents, depending entirely upon brattices (which were destroyed by the explosion), miserably perished, and the whole of the bodies could not be recovered in a week's time.

Where shafts are used of large diameter, divided by brattices, and of such large dimensions as to allow one side of the brattice to form the downcast and the other the upcast shaft, a similar result follows in the event of an explosion to that last mentioned. A part of the brattice (probably at a considerable depth) is ruptured, and no current of air can be procured to admit of its repair, except by means which involve loss of much time and expense. In the meantime all those who may have been in the pit, at the time of the explosion, cannot be approached. The author presumes that some idea of economy introduced this system; but he is satisfied upon this point an erroneous impression has prevailed. The expense of sinking these single divided shafts (of the usual diameter of 15 or 16 feet), is so very great, that it has led to the practice of working very extensive areas of coal by means of a single shaft; and this practice has further led to the different scientific contrivances for impelling the air over these immense areas, by which the ventilation of the works is rendered so much more difficult and uncertain.

Taking, for example, a pit of this description, of 15 feet diameter, by which is worked an area of 200 acres (and instances might be adduced where four, five and six times that quantity has been thus worked), it is evident that the ventilation of a coal mine of this description, where the air passages have been extended to the length of 70 miles, must be attended with very great danger and vast expense.

Now, the author states as his opinion, and thinks he should have no difficulty in proving it correct, that four shafts might have been sunk on this area of 200 acres, $7\frac{1}{2}$ feet diameter each, in proper positions with their air-chimneys, for considerably less money than the one shaft cost; and if this can be established, it follows that the 200 acres being divided into sections of 50 acres each, the expense of the underground work would have been most materially diminished, and that the ventilation might have been effected with much greater ease and security in separate sections of 50 acres each, and the power of raising coal doubled, as there would be always two ascending and two descending courses, instead of one.

To sum up the conditions and principles requisite in carrying out the author's plan effectually, it may be stated:—

1st. That the air-head should always open into the highest practicable part of the mines.

2nd. The air-head (or what may be properly called the gas-head), by which is meant the horizontal air or gas-passage, shall always be in continuous communication from the workings to a vertical air chimney, or separate shaft, of 3, 4, 5 or more feet diameter, whichever shall be required; but always of sufficient dimensions to carry off the gas and air from the workings.

3rd. That the air-head, or gas-head, shall not, in any part of its course, be depressed below the level of its opening into the workings.

4th. That the air-chimney (of such dimensions as the mine requires), by which is meant the vertical air or gas passage, shall never be used for any other purpose than the passage of the current of the gas and air from the workings to the surface; and that it shall be closed from the external air, till it arrives at its point of exit.

5th. That the vertical air-chimney should be closed at the top, and separated from the shaft, and should then be connected to the ventilated chimney, or the chimney connected by a horizontal flue with the boiler, so that the current of air may not at any time be disturbed or interrupted.

6th. That the gate roads should always be driven to the extreme point to which the workings of the coal are intended to be extended;—that the coal may previously be drained of its gas before any coal is got out: by which means the gate or horse roads, and the air or gas head, may be made, and afterwards be maintained, at considerably less expense, in a safe and secure state, and the gases be gradually drained off, before it is necessary to get the coal.

The author in conclusion states that the case may be considered as exceptional, rather than general, in which any insurmountable difficulty, in providing the remedy for accidental derangements of the coal strata will present itself, and render it necessary to interfere materially with the principles recommended for adoption.

MINIUM. (Eng. and Fr., *Red lead*; *Mennige*, Germ.) This pigment is a peculiar oxide of lead, consisting of two atoms of the protoxide and one of the peroxide; but, as found in commerce, it always contains a little extra protoxide, or yellow massicot. It is prepared by calcining lead upon a reverberatory hearth with a slow fire, and frequent renewal of the surface with a rake, till it becomes an oxide, taking care not to fuse it. The calcined mass is triturated into a fine powder in a paint mill, where it is elutriated with a stream of water, to carry off the finely levigated particles, and to deposit them afterwards in tanks. The powder thus obtained being dried, is called massicot. It is converted into minium, by being put in quantities of about 50 pounds into iron trays, 1 foot square, and 4 or 5 inches deep. These are piled up upon the reverberatory hearth, and exposed during the night, for economy of fuel, to the residuary heat of the furnace, whereby the massicot absorbs more oxygen, and becomes partially red lead. This, after being stirred about, and subjected to a similar low calcining heat once and again, will be found to form a marketable red lead.

The best minium, however, called *orange mine*, is made by the slow calcination of good white lead (carbonate) in iron trays. If the lead contains either iron or copper, it affords a minium which cannot be employed with advantage in the manufacture of flint-glass, for pottery glazes, or for house-painting.

Dumas found several samples of red lead which he examined to consist of the chemical sesquioxide and the protoxide, in proportions varying from 50 of the former and 50 of the latter, to 95·3 of the former and 4·7 of the latter. The more oxygen gas it gives out when heated, the better it is, generally speaking. See **NAPLES YELLOW**.

MINT (*Monnaie*, Fr.; *Münze*, Germ.) The chief use of gold and silver is to serve for the medium of exchange in the sale and purchase of commodities, a function for which they are pre-eminently fitted by their scarcity, by being unalterable by common agents, and condensing a great value in a small volume. It would be very inconvenient in general to barter objects of consumption against each other, because their carriage would be expensive, and their qualities, in many cases, easily injured by external agents, &c. Gold is exempt from spontaneous change, and little costly in conveyance. Mankind at a very early period recognised how much easier it was to exchange a certain weight of gold or silver for objects of commerce, than to barter these objects themselves; and thenceforth all agreed to pay for their purchases in bars or ingots of these precious metals. But as their intrinsic value depends upon their purity, it became necessary to stamp on these bars their standard quality and their weight.

The inconvenience of using ingots in general trade, on account of the difficulty of defining fractional values, has determined governments to coin pieces of money, that is, quantities of metal whose weight and standard were made known and guaranteed by the effigies of the prince. It is true, indeed, that kings have become frequently coiners

of base money, by altering the weight and purity of the pieces apparently guaranteed by their impress. By such reductions modern coins represent less of the precious metal than they did long ago. The *ordonnance* of 755, for the coining of *sous* in France, proves that there was then as much fine silver in a single *sous*, as there is now in a piece of 5 francs. During the last two centuries, indeed, silver coins have been diminished two thirds in weight.

But since knowledge has become more generally diffused, it has been shown that these frauds are equally injurious to the prince and to public faith. A sovereign may, it is true, declare by a decree that a shilling-piece is to be held worth five; but let us consider the consequences of this decree. All the individuals who have rents or capital sums to receive, will be ruined, by getting in metallic value only one-fifth of what is due to them; for although the *nominal* value should be the same as what they are entitled to, the intrinsic value would be but a fifth of the former; so that when they go to purchase the necessaries or comforts of life, the dealer who sells them will at once raise their price five-fold. Each article of merchandise would thus acquire a nominal price 5 times greater; and he who had received payment of a debt in that money, could not with it procure more than one-fifth of the goods he could have previously commanded. That fraudulent law would, therefore, favour the debtors at the expense of the creditors; and as the state is commonly a great debtor, especially when it has recourse to the depreciation of the currency, it is obvious, that however illicit the gain which it makes, it still does gain; and this is the reason why princes have so often tampered with the mint. But let us examine the other consequences of this decree.

If the sovereign is a debtor, he is also a creditor and consumer, and even the most considerable of any. The taxes which he imposes are paid him in this deteriorated money, returned to him at its nominal value; and the purveyors of his armies, his buildings, and his household, sell him their commodities only at the actual market price. We may infer from this simple development that the coin with which he pays for any object has the same intrinsic value as the object; and that the name given to the coin is of no consequence. The prince may call it a crown, a ducat, or a six-dollar at his pleasure; and he may assign any value to it that his caprice may suggest, yet this will not affect its value; for this is fixed beyond his control by the general nature of things. The prince may, indeed, at the outset, have profited by defrauding his creditors, and by authorizing each debtor to imitate him, but he will soon lose whatever he may have gained; and he will thus learn to his cost that it was bad policy to sacrifice his character by giving an example of a fraud so truly unprofitable in the issue. Moreover, he will lose still as much in the following years, because his treasury will receive only one-fifth part of the taxes, unless he has quintupled the imposts. It may be said, indeed, that he might do the one thing along with the other. But every one knows that this power is neither generally permitted to princes, nor if it were, could it be safely exercised. Serious political crises would combine to endanger the stability of the government; which besides, as the main consumer in the nation, must lose always as much as it seems to gain.

It is therefore manifest that the alteration of the standard and weight of the coinage is at once a crime and a ruinous action for the sovereign power to commit; and hence such disastrous measures have been long abandoned in all well-regulated states. A gold sovereign is intrinsically worth 20 shillings, minus the cost of coinage; for were it worth more, all our sovereign pieces would be exported or melted down, to obtain the difference of value, however trifling it might be; and were it worth less, it would be the source of loss similar to what the state occasions when it depreciates the coin.

To comprehend the true value of a coin, we must regard this piece as an article of merchandise, whose value depends, as that of every thing else, on its usefulness, the esteem in which it is held, and the demand for it in the market. Grain increases in value when there are few sellers and many buyers; gold and silver are in the same predicament. The value of these metals is much augmented, indeed, by the universal currency they obtain when struck into money; a value additional to what they possess as objects of the arts. This value of the precious metals changes with time and place, like that of every merchandise; their abundance, since the discovery of America, has greatly lowered their value; that is, with the same weight of metal, we cannot at the present day purchase the same quantity of corn, land, wool, &c. as formerly. In the countries where silver abounds, this metal has less value, or, in other terms, commodities are dearer. Hence the metal tends to resume its equilibrium in flowing into those places where it is rarer; which means, that the consumer prefers purchasing his commodities there rather than in another place, if he can easily transport them to where they are dearer.

It was formerly believed that a country is rich when it has a great deal of gold and silver; but this popular illusion has passed away. Spain has never been poorer than since the discovery of America, because its national industry has been ruined, and the

capitals merely passed through its hands to spread over the rest of Europe, from which it was obliged to import every thing that its want of home manufactures made it necessary to procure from abroad. We may add to these, the prodigalities of the court, which, supposing its wealth inexhaustible, tried to corrupt all the ministers of the other powers, in furtherance of the chimera of universal dominion. The richest state is that in which there is most industry, whereby the inhabitants may procure every thing indispensable to the conveniences and comforts of life. Gold as a useful metal, and a medium of exchange, is undoubtedly very precious, and an adequate quantity for these exchanges must be had; but as it is good for very little besides, nay, as an excess is even hurtful, it soon begins to fly of itself towards the places where it is more needed or less common.

With regard to the relative value of gold and silver, several details have already been given in our view of the mineral wealth of the globe. Three centuries ago, an ounce of gold was worth at London or Paris 10 ounces of silver; now it may be exchanged for 15 ounces and a half.

The *par* of two coins results from the comparison of their weight and standard fineness. Let us take for an example the conversion of English gold sovereigns worth 20 shillings or a pound sterling, in relation to the French louis of 20 francs. The standard of the sovereign gold is 0·917, fine gold being 1000; its weight is 125,256 gr. English, or 7·980855 grammes; by multiplying this weight into its standard, we have a product of 7·318444035; this is, in grammes, the quantity of pure gold contained in the sovereign piece. The piece of 20 francs has a legal standard of 0·9; and multiplying this number by the weight of the louis, 6·45161 grammes, we find that it contains 5·806449 of pure metal. We then make this proportion:—

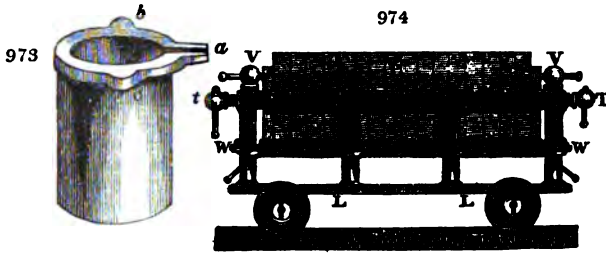
As 5·806449 : 20 francs :: 7·31844 : 25·2079 francs; or the value of the English sovereign is nearly 25·21 francs, in French gold coin. A similar calculation may be made for silver coins. The French rule for finding the *par* of a foreign gold coin, or its intrinsic value in francs, is to multiply its weight by its standard or titre, and that product by 34. The *par* of foreign silver money, or its intrinsic value in francs, is obtained by multiplying its weight in grammes by its standard in thousand parts, and by $\frac{1}{2}$. The French 5-franc piece has its standard or titre at 0·9, and weighs 25 grammes.

The assaying of gold for coin and trinkets requires very delicate management. The French take half a gramme at most (about $\frac{7}{16}$ grains) of gold, and fuse it with thrice its weight of silver, as already described under *ASSAY*. The parting is the next operation. For this purpose the button of gold and silver alloy is first hammered flat on a piece of steel, and then made feebly red hot in burning charcoal or over a lamp flame. After being thus annealed, the metal is passed through the rolling press, till it be converted into a plate about $\frac{1}{16}$ of an inch thick. After annealing this riband, it is coiled into a spiral form, introduced immediately into a small matras of a pear shape, an assay matras, and about 500 grains of nitric acid, sp. grav. 1·185, are poured over it. Heat being now applied to the vessel, the solution of the silver and copper alloys ensues, and after 22 minutes of constant ebullition, the liquid is poured off and replaced by an equal quantity of nitric acid, likewise very pure, but of the density 1·28. This is made to boil for about 10 minutes, and is then poured off, when the matras is filled up with distilled water to the brim. In conclusion, a small annealing crucible is inverted as a cup over the mouth of the matras, which is now turned upside down with a steady hand; the slip of metal falls into the crucible through the water; which by sustaining a part of its weight, softens its descent and prevents its tearing. The matras is then dexterously removed, without letting its water overflow the crucible. The water is gently decanted from the crucible, which is next covered, placed in the middle of burning charcoal, and withdrawn whenever it becomes red hot. After cooling, the metal slip is weighed very exactly, whence the weight of fine gold in the alloy is known. Stronger acid than that prescribed above would be apt to tear the metallic riband to pieces, and it would be difficult to gather the fine particles of gold together again. The metallic plate becomes at last merely a golden sieve, with very little cohesion. When copper is to be separated from gold by cupellation, a higher temperature is requisite than in cupelling silver coin.

The coining apparatus of the Royal Mint of London is justly esteemed a masterpiece of mechanical skill and workmanship. It was erected in 1811, under the direction of the inventor, Mr. Boulton; and has since been kept in almost constant employment.

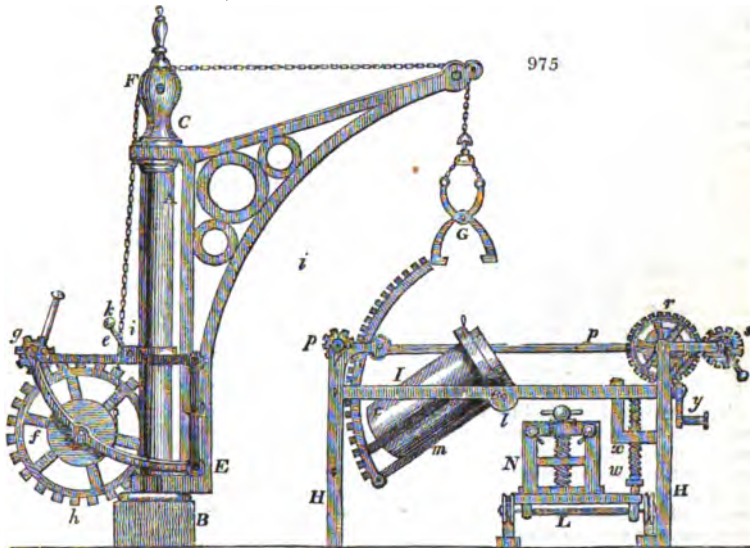
The melting pots (*fig.* 973.) are made of cast iron, and hold conveniently 400 pounds of metal. They are furnished with a spout or lip for pouring out the metal, and with two ears, on which the tongue of the crane lay hold in lifting them out of the furnace. The pot rests on pedestals on the grate of the furnace, and has a ring cast on its edge to prevent the fuel falling into it. Whenever it becomes red hot, the metal properly prepared and mixed, so as to produce an alloy containing 0·915 parts of gold, is put in, and during the melting, which occupies some hours, it is occasionally stirred. The moulds are meanwhile prepared by warming them in a stove, and thereafter by rubbing their

inside surfaces with a cloth dipped in oil, by which means the ingots cast in them get a better surface. Fig. 974. represents a side view of the carriage, charged with its



moulds. When the proper number of moulds is introduced, the screws at the end, represented at *t*, are screwed fast, to fix them all tight.

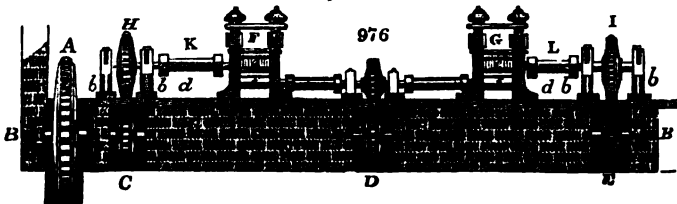
The pot of fused metal is lifted out of the furnace by the crane (fig. 975.), then



swung round, and lowered down into the cradle *l, m, n, o* of the pouring machine, until the ring on the edge of it rests on the iron hoop *n*, which, being screwed tight up, holds it secure, and the crane-tongs are removed. One of the assistants now takes the winch handle *s* in one hand, and *y* in the other. By turning *s* he inclines the pot, and pours the metal into the mould. He then fills the other moulds in succession. The first portion of liquid metal is received in a small iron spoon, and is reserved for the assay-master; a second sample is taken from the centre of the pot, and a third from the bottom part. Each of these is examined as to its quality.

The ingots, which are about 10 inches long, 7 broad, and 6 tenths of an inch thick, are now carried to the rolling mill,

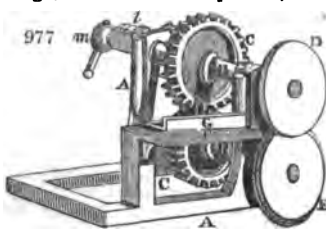
Fig. 976., where a represents a large spur wheel, fixed on the extremity of a long



horizontal shaft *s s*, extending beneath the whole mill. This wheel and shaft are driven by a smaller wheel, fixed on the main or fly-wheel shaft of a steam engine of 36-horse power. The main shaft *s* of the rolling mill has wheels *c*, *d*, *x* fixed upon it, to give motion to the respective rollers, which are mounted at *r* and *o*, in strong iron frames, bolted to the iron sills *a a*, which extend through the whole length of the mill, and rest upon the masonry, in which the wheels are concealed. The two large wheels *c* and *x* give motion to the wheels *h*, *l*, which are supported on bearings between two standards *b*, *b*, bolted down to the ground sills. On the ends of the axes of these wheels are heads for the reception of coupling boxes *d*, *d*, which unite them to short connecting shafts *k l*; and these again, by means of coupling boxes, convey motion to the upper rollers *e*, *e*, of each pair, at *r* and *o*. The middle wheel *o* upon the-main shaft *s* gives motion to the lower rollers in a similar manner. Thus both the rollers *e*, *f* of each frame receive their motion from the main shaft with equal velocity, by means of wheels of large radius, which act with much more certainty than the small pinions usually employed in rolling mills to connect the upper and lower rollers, and cause them to move together.

The rolling mill contains four pairs of rollers, each driven by its train of wheel work; the mill, therefore, consists of two such sets of wheels and rollers as are represented in our figure. The two shafts are situated parallel to each other, and receive their motion from the same steam engine. This admirable rolling mill was erected by John Rennie, Esq.

The ingots are heated to redness in a furnace before they are rolled. The two furnaces for this purpose are situated before two pairs of rollers, which, from being used to consolidate the metal by rolling whilst hot, are termed breaking-down rollers. Two men are employed in this operation; one taking the metal from the furnace with a pair of tongs, introduces it between the rollers; and the other, catching it as it comes through, lifts it over the top roller, and returns it to his fellow, who puts it through



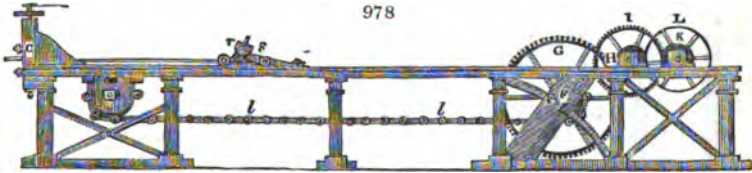
again, having previously approximated the rollers a little by their adjusting screws. After having been rolled in this manner four or five times, they are reduced to nearly two-tenths of an inch thick, and increased lengthwise to about four times the breadth of the ingot. These plates, while still warm, are rubbed over with a dilute acid or *pickle*, to remove the colour produced by the heat, and are then cut up into narrow slips across the breadth of the plate, by means of the circular shears *fig. 977*.

This machine is worked by a spur-wheel at the extremity of the main shaft *s* of the rolling mill (*fig. 976*.) It consists of a framing of iron *A A*, supporting two shafts *s s*, which are parallel to each other, and move together by means of two equal spur-wheels *c c*, the lower one of which works with the teeth of the great wheel above mentioned, upon the main shaft of the rolling mill. At the extremities of the two shafts, wheels or circular cutters are fixed with their edges overlapping each other a little way. *r* represents a shelf on which the plate is laid, and advanced forward to present it to the cutter; and *o* is a ledge or guide, screwed down on it, to conduct the metal and to regulate the breadth of the piece to be cut off. Hence the screws which fasten down the ledge are fitted in oblong holes, which admit of adjustment. The workman holds the plate flat upon the surface *r*, and pushing it towards the shears, they will lay hold of it, and draw it through until they have cut the whole length. The divided parts are also prevented from curling up into scrolls, as they do when cut by a common pair of shears; because small shoulders on *x* and *o*, behind the cutting edge, keep them straight. Behind the standard, supporting the back pivots of the shafts *s s* of the cutter, is a frame *l*, with a screw *m* tapped through it. This is used to draw the axis of the upper cutter *n* endwise, and keep its edge in close contact with the edge of the other cutter *x*. The slips or ribands of plate are now carried to the other two pairs of rollers in the rolling mill, which are made of case-hardened iron, and better polished than the breaking-down rollers. The plates are passed cold between these, to bring them to exactly the same thickness; whence they are called adjusting or planishing rollers. The workman here tries every piece by a common gauge, as it comes through. This is a piece of steel having a notch in it; the inside lines of which are very straight, and inclined to one another at a very acute angle. They are divided by fine lines, so that the edge of the plate being pressed into the notch, will have its thickness truly determined by the depth to which it enters, the divisions showing the thickness in fractions of an inch.

In rolling the plate the second time, all the plates are successively passed through the rollers; then the rollers being adjusted, they are passed through another time. This is repeated thrice or even four times; after which they are all tried by the gauge, and

thus sorted into as many parcels as there are different thicknesses. It is a curious circumstance, that though the rollers are no less than 14 inches in diameter, and their frame proportionally strong, they will yield in some degree, so as to reduce a thick plate in a less degree than a thin one; thus the plates which have all passed through the same rollers, may be of 3 or 4 different degrees of thickness, which being sorted by the gauge into as many parcels, are next reduced to the exact dimension, by adapting the rollers to each parcel. The first of the parcel which now comes through is tried, by cutting out a circular piece with a small hand machine, and weighing it. If it proves either too light or too heavy, the rollers are adjusted accordingly, till by a few such trials they are found to be correct, when all the parcel is rolled through. The trial plates which turn out to be too thin, are returned as waste to the melting-house. By these numerous precautions, the blanks or circular discs, when cut out by the next machine, will be very nearly of the same weight; which they would scarcely be, even if the gauge determined all the plates to the same thickness, because some being more condensed than others, they would weigh differently under the same volume.

A great improvement has been made on that mode of lamination, by the late Mr. Barton's machine for equalizing the thickness of slips of metal for making coin, which has been for several years introduced into the British mint. A side elevation is shown in *fig. 978.*, and a plan in *fig. 979.* It operates in the same way as wire-drawing mechanisms; namely, pulls the slips of metal forcibly through an oblong opening, left between two surfaces of hardened steel. The box or case which contains the steel dies, composed of two hardened cylinders, is represented at *c* in *fig. 978.* The pincers employed to hold the metal, and draw it through, are shown at *s r.*



The slips of metal to be operated on by the drawing machine, are first rendered thinner at one end, that they may be introduced between the dies, and also between the jaws of the pincers. This thinning of the ends is effected by another machine, consisting of a small pair of rollers, mounted in an iron frame, similar to a rolling-mill. The upper roller is cylindrical, but the lower is formed with 3 flat sides, leaving merely portions of the cylinder entire, between these flat sides. The distance between the centres of the rollers is regulated by screws, furnished with wheels on their upper ends, similar to what is seen in the drawing dies at *c.* The two rollers have pinions on their axes, which make them revolve together; they are set in motion by an endless strap passing round a drum, upon whose axis is a pinion working into the teeth of a wheel fixed upon the axis of the lower roller.

The end of a slip of metal is presented between the rollers while they are in motion, not on that side of the roller which would operate to draw in the slip between them, as in the rolling-press above described, but on the contrary side, so that when one of the flat sides of the under roller fronts horizontally the circumference of the upper roller, an opening is formed, through which the slip of metal is to be inserted until it bears against a fixed stop at the back of the rollers. As the rollers continue to turn round, the cylindrical portions come opposite to each other, and press the metal between them, forcing it outwards, and rendering the part which has been introduced between the rollers as thin as the space between their cylindrical surfaces. Thus the end of the slip of metal becomes attenuated enough to pass between the dies of the drawing machine, and to be seized by the pincers.

In using the drawing machine, a boy takes hold of the handle *s* of the pincers, their hook of connexion with the endless chain *l, l,* not shown in the present figure, being disengaged, and he moves them upon their wheels towards the die-box *c.* In this movement the jaws of the pincers get opened, and they are pushed up so close to the

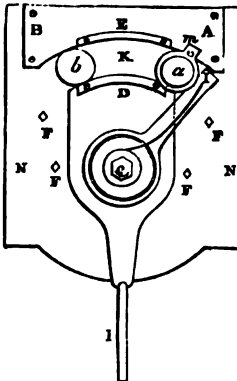
die-box that their jaws enter a hollow, which brings them near the dies, enabling them to seize the end of the slip of metal introduced between them by the action of the preparatory rollers. The boy now holds the handle *s* on the top of the pincers fast, and with his other hand draws the handle *x* backwards. Thus the jaws are closed, and the metal firmly gripped. He now presses down the handle *x* till a hook on the under side of the pincers seizes the endless chain as it moves along, when it carries the pincers, and their slip of metal, onwards with it. Whenever the whole length of the metallic riband has passed through between the dies, the strain on the pincers is suddenly relieved, which causes the weight *r* to raise their hook out of the chain, and stop their motion. The machine in the mint has two sets of dies, and two endless chains, as represented in the plan, *fig. 979*. *x x*, are toothed wheels in the upper end of the die-box, furnished with pinions and levers, for turning them round, and adjusting the distance between the dies. A large spur-wheel *a*, is fixed upon the axis *r*, to give motion to the endless chains; see both figures. This spur-wheel is turned by a pinion *u*, fixed upon an axis *m*, extending across the top of the frame, and working in bearings at each end. A spur-wheel *l*, is fixed upon the axis *m*, and works into the teeth of a pinion *k*, upon a second axis across the frame, which carries likewise a drum wheel *t*, through which motion is communicated to the whole mechanism by an endless strap.

The cutting-out machine is exhibited in *fig. 980*. *AA* is a basement of stone to support an iron plate *BB*, on which stand the columns *c c*, that bear the upper part *D* of the frame. The iron frame of the machine *x, y, z*, is fixed down upon the iron plate *BB*. The punch *d* is fixed in the lower part of the inner frame, and is moved up and down by the screw *a*, which is worked by wipers turned by a steam engine, impelling the lever *h*, and turning backwards and forwards the axis *g*, through a sufficient space for cutting the thickness of the metallic lamina. A boy manages this machine. There are twelve of them mounted on the same basement frame in a circular range contained in an elegant room, lighted from the roof. The whole are moved by a steam engine of 16-horse power.

The *blanks* or *planchets* thus cut out, were formerly adjusted by filing the edges, to bring them to the exact weight; a step which Mr. Barton's ingenious mechanism has rendered in a great measure unnecessary. The edge is then milled, by a process which Mr. Boulton desires to keep secret, and which is therefore not shown in our mint.

But the French mint employs a very elegant machine for the purpose of lettering or milling the edges, called the *cordon des monnaies*, invented by M. Gengembre, which has entirely superseded the older milling machine of M. Castaing, described in the

981



Encyclopedias. The Napoleon coins of France bear on the edge, in sunk letters, the legend, *Dieu protège la France*; and those of the king, *Domine saluum fac regem*. This is marked before striking the blank or *flan*. One machine imprints this legend, and its service is so prompt and easy, that a single man marks in a day 20,000 pieces of 5 francs, or 100,000 francs.

Each of the two arc dies *x, y*, (*fig. 981*.) carries one half of the legend, engraved in relief on the curved face; these arcs are pieces of steel tempered very hard, and fixed with two screws, one immoveably at *x*, on the sill which bears the apparatus; the other at *y*, at the extremity of the lever *r, y*, which turns round the axis *c*. The letters of these demi-legends are exactly parallel, and inscribed in an inverse order on the dies. An alternating circular motion is communicated to the handle *r*. The curvatures of the two dies are arcs of circles described from the centre *c*; and the interval which separates them, or the difference of the radii, is precisely the diameter of the piece to be milled.

As the centre *c* sustains the whole strain of the milling, and produces, of consequence, a hard friction, this axis must possess a considerable size. It is composed of a squat

truncated cone of tempered steel, which enters into an eye of the moveable piece *r, d*. This cone is kept on the plate of the metal *x x*, which bears the whole machine, by a nut, whose screw, by being tightened or slackened, gives as much freedom as is requisite for the movement of rotation, or removes the shake which hard service gives to the cone in its eye. The middle thickness of the hole of the moveable piece *r, d*, and the axis of the lever *r*, which terminates it, are exactly on a level with the engraved letters of the die, so that no strain can derange the moveable piece, or disturb the centre by its oscillations.

At *a* is a vertical tube, containing a pile of blanks for milling. It is kept constantly full; the tube being open at both ends, a little elevated above the circular space *a, x, b*, which separates the dies, and fixed by a tail *m* with a screw to the motionless piece *Δ, n*. The branch *i, c*, movable with the piece *r, d*, passes under the tube, and pushes before it the blank at the bottom of the column, which is received into a small excavation in the form of a circular step, and carried forwards. Matters are thus so arranged as to regulate the issue of the blanks, one by one, on the small step, called the *posoir* (bed.)

As soon as the blank is pushed forwards into contact with the lower edge of the engraved grooves, it is seized by them, and carried on by the strain of milling, without exposing the upper or under surfaces of the *blank* to any action which may obstruct the printing on its edge.

The blank is observed to revolve between the two dies according as the lever *r* completes its course, and this blank passing from *a* to *x*, then to *b*, meets a circular aperture *b*, through which it falls into a drawer placed under the sill.

The range of the movable lever *r* is regulated by four pieces, *r, r, r, r*, solidly sunk in the plate *x, x*, which bears the whole apparatus. A stud placed on this lever towards *d*, makes the arm of the *posoir* *i* retire no farther than is necessary for the little blank to issue from the column; and a spring fixed to the centre *c*, and supported on a peg, brings back the *posoir*; so that when a screw *i* comes to strike against the column, the *posoir* stops, and the movable die *d*, which continues its progress, finds the blank in a fit position for pressing, seizing, and carrying it on, by reaction of the fixed die *x*. Thus the edge of the blank is lettered in half a second. A hundred may easily be marked in about three minutes.

The coining press is the most beautiful part of the whole mechanism in the British mint; but the limits of this volume will not allow of its being figured upon an adequate scale. An engraving of it may be seen in the *Encyclopaedia Britannica*.

The only attention which this noble machine requires is that of a little boy, who stands in a sunk place before the press, and always keeps the tube full of blanks. He has two strings, one of which, when pulled, will put the press in motion by the concealed mechanism in the apartment above; and the other string, when snatched, stops the press. This coining operation goes on at the rate of 60 or 70 strokes per minute; and with very few interruptions during the whole day. The press-room at the Royal Mint contains eight machines, all supported on the same stone base; and the iron beams between the columns serve equally for the presses on each side. The whole has therefore a magnificent appearance. The eight presses will strike more than 19,000 coins in an hour, with only a child to supply each. The grand improvement in these presses, consists; 1. in the precision with which they operate to strike every coin with equal force, which could not be ensured by the old press impelled by manual labour; 2. The rising collar or steel ring in which they are struck, keeps them all of one size, and makes a fair edge, which was not the case with the old coins, as they were often rounded and defaced by the expansion of the metal under the blow; 3. The twisting motion of the upper die is thought to produce a better surface on the flat parts of the coin; but this is somewhat doubtful; 4. The feeding mechanism is very complete, and enables the machine to work much quicker than the old press did, where the workman, being in constant danger of having his fingers caught, was obliged to proceed cautiously, as well as to place the coin true on the die, which was seldom perfectly done. The feeding mechanism of the above press is a French invention; but Mr. Boulton is supposed to have improved upon it.

MIRRORS. See COPPER and GLASS.

MISPICKEL, is arsenical pyrites.

MOHAIR, is the hair of a goat which inhabits the mountains in the vicinity of Angora, in Asia Minor.

MOIRE'E METALLIQUE, called in this country crystallized tin-plate, is a variegated primrose appearance, produced upon the surface of tin-plate, by applying to it in a heated state some dilute nitro-muriatic acid for a few seconds, then washing it with water, drying, and coating it with lacquer. The figures are more or less beautiful and diversified, according to the degree of heat, and relative dilution of the acid. This mode of ornamenting tin-plate is much less in vogue now than it was a few years ago.

MOLASSE, is a sandstone belonging to the tertiary strata, employed under that name by the Swiss for building.

MOLASSES, is the brown viscid uncrystallizable liquor, which drains from cane sugar in the colonies. See *SUGAR*.

MOLYBDENUM (*Molybdène*, Fr.; *Molybdan*, Germ.); is a rare metal which occurs in nature sometimes as a sulphuret, sometimes as molybdic acid, and at others as molybdate of lead. Its reduction from the acid state by charcoal requires a very high heat, and affords not very satisfactory results. When reduced by passing hydrogen over the ignited acid, it appears as an ash-gray powder, susceptible of acquiring metallic lustre by being rubbed with a steel burnisher; when reduced and fused with charcoal, it possesses a silver white colour, is very brilliant, hard, brittle, of specific gravity 8.6; it melts in a powerful air-furnace, oxidizes with heat and air, burns at an intense heat into molybdic acid, dissolves in neither dilute sulphuric, muriatic, nor fluoric acids, but in the concentrated sulphuric and nitric.

The protoxide consists of 85.69 of metal, and 14.31 of oxygen; the deutoxide consists of 75 of metal, and 25 of oxygen; and the peroxide, or molybdic acid, of 66.6 of metal, and 33.4 of oxygen. These substances are too rare at present to be used in any manufacture.

MORDANT, in dyeing and calico-printing, denotes a body which, having a twofold attraction for organic fibres and colouring particles, serves as a bond of union between them, and thus gives fixity to dyes; or it signifies a substance which, by combining with colouring particles in the pores of textile filaments, renders them insoluble in hot soapy and weak alkaline solutions. In order properly to appreciate the utility and the true functions of mordants, we must bear in mind that colouring matters are peculiar compounds possessed of certain affinities, their distinctive characters being not to be either acid or alkaline, and yet to be capable of combining with many bodies, and especially with salifiable bases, and of receiving from each of them modifications in their colour, solubility, and alterability. Organic colouring substances, when pure, have a very energetic attraction for certain bodies, feeble for others, and none at all for some. Among these immediate products of animal or vegetable life, some are soluble in pure water, and others become so only through peculiar agents. We may thus readily conceive, that whenever a dye-stuff possesses a certain affinity for the organic fibre, it will be able to become fixed on it, or to dye it without the intervention of mordants, if it be insoluble by itself in water, which, in fact, is the case with the colouring matters of safflower, annotto, and indigo. The first two are soluble in alkalis; hence, in order to use them, they need only be dissolved in a weak alkaline lye, be thus applied to the stuff, and then have their tinctorial substance precipitated within their pores, by abstracting their solvent alkali with an acid. The colouring matter, at the instant of ceasing to be liquid, is in an extremely divided state, and is in contact with the organic fibres for which it has a certain affinity. It therefore unites with them, and, being naturally insoluble in water, that is, having no affinity for this vehicle, the subsequent washings have no effect upon the dye. The same thing may be said of indigo, although its solubility in the dye-bath does not depend upon a similar cause, but is due to a modification of its constituent elements, in consequence of which it becomes soluble in alkalis. Stuffs plunged into this indigo bath get impregnated with the solution, so that when again exposed to the air, the dyeing substance resumes at once its primitive colour and insolubility, and washing can carry off only the portions in excess above the intimate combination, or which are merely deposited upon the surface of the stuff.

Such is the result with insoluble colouring matters; but for those which are soluble it should be quite the reverse, since they do not possess an affinity for the organic fibres which can counterbalance their affinity for water. In such circumstances, the dyer must have recourse to intermediate bodies, which add their affinity for the colouring matter to that possessed by the particles of the stuff, and increase by this twofold action the intimacy and the stability of the combination. These intermediate bodies are the true *mordants*.

Mordants are in general found among the metallic bases or oxides; whence they might be supposed to be very numerous, like the metals; but as they must unite the twofold condition of possessing a strong affinity for both the colouring matter and the organic fibre, and as the insoluble bases are almost the only ones fit to form insoluble combinations, we may thus perceive that their number may be very limited. It is well known, that although lime and magnesia, for example, have a considerable affinity for colouring particles, and form insoluble compounds with them, yet they cannot be employed as mordants, because they possess no affinity for the textile fibres.

Experience has proved, that of all the bases, those which succeed best as mordants are alumina, tin, and oxide of iron; the first two of which, being naturally white, are the only ones which can be employed for preserving to the colour its original tint, at least

without much variation. But whenever the mordant is itself coloured, it will cause the dye to take a compound colour quite different from its own. If, as is usually said, the mordant enters into a real chemical union with the stuff to be dyed, the application of the mordant should obviously be made in such circumstances as are known to be most favourable to the combination taking place; and this is the principle of every day's practice in the dyehouse.

In order that a combination may result between two bodies, they must not only be in contact, but they must be reduced to their ultimate molecules. The mordants that are to be united with stuffs are, as we have seen, insoluble of themselves, for which reason their particles must be divided by solution in an appropriate vehicle. Now this solvent or menstruum will exert in its own favour an affinity for the mordant, which will prove to that extent an obstacle to its attraction for the stuff. Hence we must select such solvents as have a weaker affinity for the mordants than the mordants have for the stuff. Of all the acids which can be employed to dissolve alumina, for example, vinegar is the one which will retain it with least energy, for which reason the acetate of alumina is now generally substituted for alum, because the acetic acid gives up the alumina with such readiness, that mere elevation of temperature is sufficient to effect the separation of these two substances. Before this substitution of the acetate, alum alone was employed; but without knowing the true reason, all the French dyers preferred the alum of Rome, simply regarding it to be the purest; it is only within these few years that they have understood the real grounds of this preference. This alum has not, in fact, the same composition as the alums of France, England, and Germany, but it consists chiefly of cubic alum having a larger proportion of base. Now this extra portion of base is held by the sulphuric acid more feebly than the rest, and hence is more readily detached in the form of a mordant. Nay, when a solution of cubic alum is heated, this redundant alumina falls down in the state of a subsulphate, long before it reaches the boiling point. This difference had not, however, been recognised, because Roman alum, being usually soiled with ochre on the surface, gives a turbid solution, whereby the precipitate of subsulphate of alumina escaped observation. When the liquid was filtered, and crystallized afresh, common octahedral alum alone was obtained; whence it was most erroneously concluded, that the preference given to Roman alum was unjustifiable, and that its only superiority was in being freer from iron.

Here a remarkable anecdote illustrates the necessity of extreme caution, before we venture to condemn from theory a practice found to be useful in the arts, or set about changing it. When the French were masters in Rome, one of their ablest chemists was sent thither to inspect the different manufactures, and to place them upon a level with the state of chemical knowledge. One of the fabrics, which seemed to him furthest behindhand, was precisely that of alum, and he was particularly hostile to the construction of the furnaces, in which vast boilers received heat merely at their bottoms, and could not be made to boil. He strenuously advised them to be new modelled upon a plan of his own; but, notwithstanding his advice, which was no doubt very scientific, the old routine kept its ground, supported by utility and reputation, and very fortunately, too, for the manufacture; for had the higher heat been given to the boilers, no more genuine cubical alum would have been made, since it is decomposed at a temperature of about 120° F., and common octahedral alum would alone have been produced. The addition of a little alkali to common alum brings it into the same basic state as the alum of Rome.

The two principal conditions, namely, extreme tenuity of particles, and liberty of action, being found in a mordant, its operation is certain. But as the combination to be effected is merely the result of a play of affinity between the solvent and the stuff to be dyed, a sort of partition must take place, proportioned to the mass of the solvent, as well as to its attractive force. Hence the stuff will retain more of the mordant when its solution is more concentrated, that is, when the base diffused through it is not so much protected by a large mass of menstruum; a fact applied to very valuable uses by the practical man. On impregnating in calico printing, for example, different spots of the same web with the same mordant in different degrees of concentration, there is obtained in the dye-bath a depth of colour upon these spots intense in proportion to the strength of their various mordants. Thus, with solution of acetate of alumina in different grades of density, and with madder, every shade can be produced, from the fullest red to the lightest pink; and, with acetate of iron and madder, every shade from black to pale violet.

We hereby perceive that recourse must indispensably be had to mordants at different stages of concentration; a circumstance readily realized by varying the proportions of the watery vehicle. See CALICO-PREPARATION and Madder. When these mordants are to be topically applied, to produce partial dyes upon cloth, they must be thickened with starch or gum, to prevent their spreading, and to permit a sufficient body of them to become attached to the stuff. Starch answers best for the more neutral mordants, and

gum for the acidulous; but so much of them should never be used, as to impede the attraction of the mordant for the cloth. Nor should the thickened mordants be of too desiccative a nature, lest they become hard, and imprison the chemical agent before it has had an opportunity of combining with the cloth, during the slow evaporation of its water and acid. Hence the mordanted goods, in such a case, should be hung up to dry in a gradual manner, and when oxygen is necessary to the fixation of the base, they should be largely exposed to the atmosphere. The foreman of the factory ought, therefore, to be thoroughly conversant with all the minutiae of chemical reaction. In cold and damp weather he must raise the temperature of his drying-house, in order to command a more decided evaporation; and when the atmosphere is unusually dry and warm, he should add deliquescent correctives to his thickening, as I have particularized in treating of some styles of calico-printing. But, supposing the application of the mordant and its desiccation to have been properly managed, the operation is by no means complete; nay, what remains to be done is not the least important to success, nor the least delicate of execution. Let us bear in mind that the mordant is intended to combine not only with the organic fibre, but afterwards also with the colouring matter, and that, consequently, it must be laid entirely bare, or scraped clean, so to speak, that is, completely disengaged from all foreign substances which might invest it, and obstruct its intimate contact with the colouring matters. This is the principle and the object of two operations, to which the names of *dunging* and *clearing* have been given.

If the mordant applied to the surface of the cloth were completely decomposed, and the whole of its base brought into chemical union with it, a mere rinsing or scouring in water would suffice for removing the viscid substances added to it, but this never happens, whatsoever precautions may be taken; one portion of the mordant remains untouched, and besides, one part of the base of the portion decomposed does not enter into combination with the stuff, but continues loose and superfluous. All these particles, therefore, must be removed without causing any injury to the dyes. If in this predicament the stuff were merely immersed in water, the free portion of the mordant would dissolve, and would combine indiscriminately with all the parts of the cloth not mordanted, and which should be carefully protected from such combination, as well as the action of the dye. We must therefore add to the scouring water some substance that is capable of seizing the mordant as soon as it is separated from the cloth, and of forming with it an insoluble compound; by which means we shall withdraw it from the sphere of action, and prevent its affecting the rest of the stuff, or interfering with the other dyes. This result is obtained by the addition of cow-dung to the scouring bath; a substance which contains a sufficiently great proportion of soluble animal matters, and of colouring particles, for absorbing the aluminous and ferruginous salts. The heat given to the dung-bath accelerates this combination, and determines an insoluble and perfectly inert coagulum.

Thus the dung-bath produces at once the solution of the thickening paste; a more intimate union between the alumina or iron and the stuff, in proportion to its elevation of temperature, which promotes that union; an effectual subtraction of the undecomposed and superfluous part of the mordant, and perhaps a commencement of mechanical separation of the particles of alumina, which are merely dispersed among the fibres; a separation, however, which can be completed only by the proper scouring, which is done by the dash-wheel with such agitation and pressure (see BLEACHING and DUNGING) as vastly facilitate the expulsion of foreign particles. See also BRAN.

Before concluding this article, we may say a word or two about astringents, and especially gall-nuts, which have been ranked by some writers among mordants. It is rather difficult to account for the part which they play. Of course we do not allude to their operation in the black dye, where they give the well known purple-black colour with salts of iron; but to the circumstance of their employment for madder dyes, and especially the Adrianople red. All that seems to be clearly established is, that the astringent principle or tannin, whose peculiar nature in this respect is unknown, combines like mordants with the stuffs and the colouring substance, so as to fix it; but as this tannin has itself a brown tint, it will not suit for white grounds, though it answers quite well for pink grounds. When white spots are desired upon a cloth prepared with oil and galls, they are produced by an oxygenous discharge, effected either through chlorine or chromic acid.

MORDANT, is also the name sometimes given to the adhesive matter by which gold-leaf is made to adhere to surfaces of wood and metal in gilding. Paper, vellum, taffety, &c., are easily gilt by the aid of different mordants, such as the following: 1. beer in which some honey and gum arabic have been dissolved; 2. gum arabic, sugar, and water; 3. the viscid juice of onion or hyacinth, strengthened with a little gum arabic. When too much gum is employed, the silver or gold leaf is apt to crack in the drying of the mordant. A little carmine should be mixed with the above colourless

liquids, to mark the places where they are applied. The foil is applied by means of a dossil of cotton wool, and when the mordant has become hard, the foil is polished with the same.

The best medium for sticking gold and silver leaf to wood, is the following, called *mirtion* by the French artists:—1 pound of amber is to be fused, with 4 ounces of mastic in tears, and 1 ounce of Jewish pitch, and the whole dissolved in 1 pound of linseed oil rendered drying by litharge.

Painters in distemper sometimes increase the effect of their work, by patches of gold leaf, which they place in favourable positions; they employ the above mordant. The manufacturers of paper hangings of the finer kinds attach gold and silver leaf to them by the same varnish.

MOROCCO. See **LEATHER.**

MORPHIA (*Morphine*, Fr.; *Morphin*, Germ.), is a vegeto-alkali which exists associated with opian, codeine, narcotine, meconine, meconic acid, resin, gum, bassorine, lignine, fat oil, caoutchouc, extractive, &c., in opium. Morphia is prepared as follows: Opium in powder is to be repeatedly digested with dilute muriatic acid, slightly heated, and sea-salt is to be added, to precipitate the opian. The filtered liquid is to be supersaturated with ammonia, which throws down the morphia, along with the meconine, resin, and extractive. The precipitate is to be washed with water, heated, and dissolved in dilute muriatic acid; the solution is to be filtered, whereby the foreign matters are separated from the salt of morphia, which concretes upon cooling, while the meconine remains in the acid liquid. The muriate of morphia having been squeezed between folds of blotting paper, is to be sprinkled with water, again squeezed, next dissolved in water, and decomposed by water of ammonia. The precipitate, when washed, dried, dissolved in alcohol, and crystallized, is morphia.

These crystals, which contain 6.32 per cent. of combined water, are transparent, colourless, four-sided prisms, without smell, and nearly void of taste, fusible at a moderate heat, and then congregate into a radiated translucent mass, but at a higher temperature they grow purple-red. Morphia consists of 72.34 of carbon; 6.366 of hydrogen; 5 of azote; and 16.3 of oxygen. It burns with a red and very smoky flame, is stained red by nitric acid, is soluble in 90 parts of boiling anhydrous alcohol, in 500 parts of boiling water, but hardly if at all in cold water, and is insoluble in ether and oils. The solutions have a strong bitter taste, and an alkaline reaction upon litmus paper. The saline compounds have a bitter taste, are mostly crystallizable, are soluble in water and alcohol (but not in ether), and give a blue colour to the peroxide salts of iron. It is a very poisonous substance. Acetate of morphia is sometimes prescribed, instead of opium, in medicine.

Preparation of Morphia.—The aqueous extract of opium is to be concentrated by evaporation, and mixed with chloride of tin, till no further precipitate appears. The liquid is then allowed to settle, is poured off, the precipitate is washed, and the washings mixed with the poured off liquid. To this mixture is then added ammonia, and the precipitate which it produces is to be digested with ether, in order to remove the narcotine; and then with alcohol, as long as the latter acquires a bitter taste. The alcohol being then partially removed by distillation, the pure morphia is obtained in the form of crystals.

MORTAR, HYDRAULIC, called also *Roman Cement*, is the kind of mortar used for building piers, or walls under or exposed to water, such as those of harbours, docks, &c. The poorer sorts of limestone are best adapted for this purpose, such as contain from 8 to 25 per cent. of foreign matter, in silica, alumina, magnesia, &c. These, though calcined, do not slake when moistened; but if pulverized they absorb water without swelling up or heating, like *fat lime*, and afford a paste which hardens in a few days under water, but in the air they never acquire much solidity. Smeaton first discovered these remarkable facts, and described them in 1759.

The following analyses of different hydraulic limestones, by Berthier, merit confidence [see next page]:—

No. 1. is from the fresh-water lime formation of Chateau-Landon, near Nemours; No. 2. the large-grained limestone of Paris; both of these afford a fat lime when burnt; Dolomite affords a pretty fat lime, though it contains 42 per cent. of carbonate of magnesia; No. 3. is a limestone from the neighbourhood of Paris, which yields a poor lime, possessing no hydraulic property; No. 4. is the secondary limestone of Metz; No. 5. is the lime marl of Senonches, near Dreux; both the latter have the property of hardening under water, particularly the last, which is much used at Paris on this account.

All good hydraulic mortars must contain alumina and silica; the oxides of iron and manganese, at one time considered essential, are rather prejudicial ingredients. By adding silica and alumina, or merely the former, in certain circumstances, to fat lime, a water-cement may be artificially formed; as also by adding to lime any of the following native productions, which contain silicates; puzzolana, traas or tarra, pumice-stone, basalt-tuff, slate clay. Puzzolana is a volcanic product, which forms hills of consider-

| | No. 1. | No. 2. | No. 3. | No. 4. | No. 5. |
|---------------------------------------|--------|--------|--------|--------|--------|
| A. Analyses of limestones. | | | | | |
| Carbonate of lime - - | 97.0 | 98.5 | 74.5 | 76.5 | 80.0 |
| Carbonate of magnesia - - | 2.0 | — | 23.0 | 3.0 | 1.5 |
| Carbonate of protoxide of iron | — | — | — | 3.0 | — |
| Carbonate of manganese - - | — | — | — | 1.5 | — |
| Silica and alumina - - - | — | — | — | 15.2 | — |
| Oxide of iron - - - | 1.0 | 1.5 | 1.2 | — | 18.0 |
| | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| B. Analyses of the burnt lime. | | | | | |
| Lime - - - - | 96.4 | 97.2 | 78.0 | 68.3 | 70.0 |
| Magnesia - - - - | 1.8 | — | 20.0 | 2.0 | 1.0 |
| Alumina - - - - | 1.8 | 2.8 | 2.0 | 24.0 | 29.0 |
| Oxide of iron - - - - | — | — | — | 5.7 | — |
| | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

able extent to the south-west of the Apennines, in the district of Rome, the Pontine marshes, Viterbo, Bolsena, and in the Neapolitan region of Puzzuolo, whence the name. A similar volcanic tufa is found in many other parts of the world. According to Berthier, the Italian puzzolana consists of 44.5 silica; 15.0 alumina; 8.8 lime; 4.7 magnesia; 1.4 potash; 4.1 soda; 12 oxides of iron and titanium; 9.2 water; in 100 parts.

The tufa stone, which when ground forms *trass*, is composed of 57.0 silica, 16.0 clay, 2.6 lime, 1.0 magnesia, 7.0 potash, 1.0 soda, 5 oxides of iron and titanium, 9.6 water. This tuff is found abundantly filling up valleys in beds of 10 or 20 feet deep, in the north of Ireland, among the schistose formations upon the banks of the Rhine, and at Monheim in Bavaria.

The fatter the lime, the less of it must be added to the ground puzzolana or trass, to form a hydraulic mortar; the mixture should be made extemporaneously, and must at any rate be kept dry till about to be applied. Sometimes a proportion of common sand mortar instead of lime is mixed with the trass. When the hydraulic cement hardens too soon, as in 12 hours, it is apt to crack; it is better when it takes 8 days to concrete. Through the agency of the water, silicates of lime, alumina, (magnesia), and oxide of iron are formed, which assume a stony hardness.

Besides the above two volcanic products, other native earthy compounds are used in making water cements. To this head belong all limestones which contain from 20 to 30 per cent. of clay and silica. By gentle calcination, a portion of the carbonic acid is expelled, and a little lime is combined with the clay, while a silicate of clay and lime results, associated with lime in a subcarbonated state. A lime-marl containing less clay will bear a stronger calcining heat without prejudice to its qualities as a hydraulic cement; but much also depends upon the proportion of silica present, and the physical structure of all the constituents.

The mineral substance most used in England for making such mortar is vulgarly called *cement-stone*. It is a reniform limestone, which occurs distributed in single nodules or rather lenticular cakes, in beds of clay. They are mostly found in those argillaceous strata which alternate with the limestone beds of the oolite formation, as also in the clay strata above the chalk, and sometimes in the London clay. On the coasts of Kent, in the isles of Sheppey and Thanet, on the coasts of Yorkshire, Somersetshire, and the Isle of Wight, &c., these nodular concretions are found in considerable quantities, having been laid bare by the action of the sea and weather. They were called by the older mineralogists *Septaria* and *Ludus Helmontii* (Van Helmont's coits). When sawn across, they show veins of calc-spar traversing the siliceous clay, and are then sometimes placed in the cabinets of *virtuosi*. They are found also in several places on the Continent, as at Neustadt-Eberswalde, near Antwerp, near Altdorf in Bavaria; as also at Boulogne-sur-mer, where they are called Boulogne-pebbles (*galets*). These nodules vary in size from that of a fist to a man's head; they are of a yellow-gray or brown colour, interspersed with veins of calc-spar, and sometimes contain cavities bestudded with crystals. Their specific gravity is 2.59.

Analyses of several cement-stones, and of the cement made with them:—

| | No. 1. | No. 2. | No. 3. | No. 4. | No. 5. |
|--|--------|--------|--------|--------|--------|
| A. Constituents of the cement-stones. | | | | | |
| Carbonate of lime - - | 65·7 | 61·6 | - - | 82·9 | 63·8 |
| — magnesia - - | 0·5 | - - | - - | - - | 1·5 |
| — protoxide of iron - - | 6·0 | 6·0 | - - | - - | 11·6 |
| — manganese - - | 1·6 | - - | - - | 4·3 | - - |
| Silica - - | 18·0 | 15·0 | - - | 13·0 | 14·0 |
| Alumina or clay - - | 6·6 | 4·8 | - - | trace | 5·7 |
| Oxide of iron - - | - - | 3·0 | - - | - - | - - |
| Water - - | 1·2 | 6·6 | - - | - - | 9·4 |
| B. Constituents of the cement. | | | | | |
| Lime - - | 55·4 | 54·0 | 55·0 | - - | 56·6 |
| Magnesia - - | - - | - - | - - | - - | 1·1 |
| Alumina or clay - - | 36·0 | 31·0 | 38·0 | - - | 21·0 |
| Oxide of iron - - | 8·6 | 15·0 | 13·0 | - - | 13·7 |

No. 1. English cement-stone, analyzed by Berthier; No. 2. Boulogne stone, by Drapiez; No. 3. English ditto, by Davy; No. 4. remifrom limestone nodules from Arkona, by Hühnefeld; No. 5. cement-stone of Avallon, by Dumas.

In England the stones are calcined in shaft-kilns, or sometimes in mound-kilns, then ground, sifted, and packed in casks. The colour of the powder is dark-brown-red. When made into a thick paste with water, it absorbs little of it, evolves hardly any heat, and soon indurates. It is mixed with sharp sand in various proportions, immediately before using it; and is employed in all marine and river embankments, for securing the seams of stone or brick floors or arches from the percolation of moisture, and also for facing walls to protect them from damp.

The cement of Pouilly is prepared from a Jurassic (secondary) limestone, which contains 39 per cent. of silica, with alumina, magnesia, and iron oxide. Vicat forms a factitious Roman cement by making bricks with a pasty mixture of 4 parts of chalk, and 1 part of dry clay, drying, burning, and grinding them. River sand must be added to this powder; and even with this addition, its efficacy is somewhat doubtful; though it has, for want of a better substitute, been much employed at Paris.

The cement of Dibl consists of porcelain or salt-glaze potsherds ground fine, and mixed with boiled linseed oil.

Hamelin's mastic or lithic paint to cover the façades of brick buildings, &c., is composed of 50 measures of siliceous sand, 50 of lime-marl, and 9 of litharge or red-lead ground up with linseed oil.

Professor Kuhlmann, of Lisle, obtained a patent in April, 1841, in the name of Mr. Newton, for certain improvements in the manufacture of lime-cement and artificial stone; and of which he gave me a sample, possessed of a hardness and solidity fit for the sculptor.

In operating by the dry method, instead of calcining the limestone with sand and clay alone, as has been hitherto practised, this inventor introduces a small quantity of soda, or, preferably, potash, in the state of sulphate, carbonate, or muriate; salts susceptible of forming silicates when the earthy mixture is calcined. The alkaline salt, equal in weight to about one-fifth that of the lime, is introduced in solution among the earths.

All sorts of lime are made hydraulic, in the humid way, by mixing slaked lime with solutions of common alum or sulphate of alumina; but the best method consists in employing a solution of the silicate of potash, called liquor of flints, or soluble glass, to mix in with the lime, or lime and clay. An hydraulic cement may also be made which will serve for the manufacture of architectural ornaments, by making a paste of pulverized chalk, with a solution of the silicate of potash. The said liquor of flints likewise gives chalk and plaster a stony hardness, by merely soaking them in it after they are cut or moulded to a proper shape. On exposure to the air, they get progressively indurated. Superficial hardness may be readily procured by washing over the surface of chalk, &c., with liquor of flints, by means of a brush. This method affords an easy and elegant method of giving a stony crust to plastered walls and ceilings of apartments; as also to statues and busts, cast in gypsum, mixed with chalk.

The essential constituents of every good hydraulic mortar are caustic lime and silica; and the hardening of this compound under water consists mainly in a chemical combination of these two constituents through the agency of the water, producing a

hydrated silicate of lime. But such mortars may contain other bases besides lime, as for example clay and magnesia, whence double silicates of great solidity are formed; on which account dolomite is a good ingredient of these mortars. But the silica must be in a peculiar state for these purposes; namely, capable of affording a gelatinous paste with acids; and if not so already, it must be brought into this condition, by calcining it along with an alkali or an alkaline earth, at a bright red heat, when it will dissolve, and gelatinize in acids. Quartzose sand, however fine its powder may be, will form no water mortar with lime; but if the powder be ignited with the lime, it then becomes fit for hydraulic work. Ground felspar or clay forms with slaked lime no water cement; but when they are previously calcined along with the lime, the mixture becomes capable of hardening under water.

The mastic called *Hamelin's*, and so much employed in London, is composed of ground Portland stone (roe stone), sand and litharge in the proportion of 62 of the first, 35 of the second, and 3 of the third, in 100 parts; but other proportions will also answer the purpose. I find that chalk will not make a good mastic; being too compact to permit the air to insinuate between the pores, and to produce the concretion of the linseed oil, with which the above mixture is worked up and applied. This mastic soon acquires great hardness, and is totally impervious to water. The surface to which it is to be applied must be dry, and smeared over with linseed oil. Considerable dexterity is required to make good work with it. The fine dust of sandstone alone, mixed with 10 or 12 per cent. of litharge and 7 per cent. of linseed oil, forms an excellent mastic.

Limestone, which contains as much as 10 per cent. of clay, comports itself after calcination, if all the carbonic acid be expelled, just as pure limestone would do. When it is less strongly burned, it affords, however, a mass which hardens pretty speedily in water. If the argillaceous proportion of a marl amounts to 18 or 20 per cent., it still will slake with water, but it will absorb less of it, and forms a tolerably good hydraulic mortar, especially if a little good Roman cement be added to it. When the proportion of clay is 25 or 30 per cent. after burning, it heats but little with water, nor does it slake well, and must therefore be ground by stampers or an edge millstone, when it is to be used as a mortar. This kind of marl yields commonly the best water cement without other addition. Should the quantity of clay be increased farther, as up to 40 per cent., the compound will not bear a high or long-continued heat without being spoiled for making hydraulic mortar after grinding to powder. When more strongly calcined, it forms a vitriform substance, and should, after being pulverized, be mixed up with good lime, to make a water mortar. If the marls, in any locality, differ much in their relative proportions of lime and alumina, as may be readily ascertained by the use of my lime-proof apparatus (see *Appendix*), then the several kinds should be mixed in such due proportions as to produce the most speedily setting, and most highly indurating hydraulic cement. See *SOILS, A ANALYSIS OF*.

MOSAIC GOLD. For the composition of this peculiar alloy of copper and zinc, called also *Or-molu*, Messrs. Parker and Hamilton obtained a patent in November, 1825. Equal quantities of copper and zinc are to be "melted at the lowest temperature that copper will fuse," which being stirred together so as to produce a perfect admixture of the metals, a further quantity of zinc is added in small portions, until the alloy in the melting pot becomes of the colour required. If the temperature of the copper be too high, a portion of the zinc will fly off in vapour, and the result will be merely spelter or hard solder; but if the operations be carried on at as low a heat as possible, the alloy will assume first a brassy yellow colour; then, by the introduction of small portions of zinc, it will take a purple or violet hue, and will ultimately become perfectly white; which is the appearance of the proper compound in its fused state. This alloy may be poured into ingots; but as it is difficult to preserve its character when re-melted, it should be cast directly into the figured moulds. The patentees claim the exclusive right of compounding a metal consisting of from 52 to 55 parts of zinc, out of 100.

Mosaic gold, the *aurum musivum* of the old chemists, is a sulphuret of tin.

MOSAIC. (*Mosaïque*, Fr.; *Mosaisch*, Germ.) There are several kinds of mosaic, but all of them consist in imbedding fragments of different coloured substances, usually glass or stones, in a cement, so as to produce the effect of a picture. The beautiful chapel of Saint Lawrence in Florence, which contains the tombs of the Medici, has been greatly admired by artists, on account of the vast multitude of precious marbles, jaspers, agates, aventurines, malachites, &c., applied in mosaic upon its walls. The detailed discussion of this subject belongs to a treatise upon the fine arts.

MOTHER OF PEARL (*Nacre de Perles*, Fr.; *Perlen mutter*, Germ.); is the hard, silvery, brilliant internal layer of several kinds of shells, particularly oysters, which is often variegated with changing purple and azure colours. The large oysters of the Indian seas alone secrete this coat of sufficient thickness to render their shells available to the purposes of manufactures. The genus of shell fish called *pentadina* furnishes the finest pearls, as well as mother of pearl; it is found in greatest perfection round the

coasts of Ceylon, near Ormus in the Persian Gulf, at Cape Comorin, and among some of the Australian seas. The brilliant hues of mother of pearl do not depend upon the nature of the substance, but upon its structure. The microscopic wrinkles or furrows which run across the surface of every slice, act upon the reflected light in such a way as to produce the chromatic effect; for Sir David Brewster has shown, that if we take, with very fine black wax, or with the fusible alloy of D'Arcet, an impression of mother of pearl, it will possess the iridescent appearance. Mother of pearl is very delicate to work, but it may be fashioned by saws, files, and drills, with the aid sometimes of a corrosive acid, such as the dilute sulphuric or muriatic; and it is polished by colcothar of vitriol.

MOTHER-WATER, is the name of the liquid which remains after all the salts that will regularly crystallize have been extracted, by evaporation and cooling, from any saline solution.

MOUNTAIN SOAP (*Savon de montagne*, Fr.; *Bergseife*, Germ.); is a tender mineral, soft to the touch, which assumes a greasy lustre when rubbed, and falls to pieces in water. It consists of silica 44, alumina 26·5, water 20·5, oxide of iron 8, lime 0·5. It occurs in beds, alternating with different sorts of clay, in the Isle of Skye, at Billin in Bohemia, &c. It has been often, but improperly, confounded with steatite.

MUCIC ACID (*Acid mucique*, Fr.; *Schleimsäure*, Germ.); is the same as the saccharic acid of Scheele, and may be obtained by digesting one part of gum arabic, sugar of milk, or pectic acid, with twice or thrice their weight of nitric acid. It forms white granular crystals, and has not been applied to any use in the arts.

MUCILAGE, is a solution in water of gummy matter of any kind.

MUFFLE, is the earthenware case or box, in the assay furnaces, for receiving the cupels, and protecting them from being disturbed by the fuel. See **ASSAY FURNACE**.

MUNDIC, is the name of iron or arsenical pyrites among Cornish miners.

MUNJEET, is a kind of madder grown in several parts of India.

MURIATIC or **HYDROCHLORIC ACID**; anciently *marine acid* and *spirit of salt*. (*Acide hydrochlorique* and *Chlorhydrique*, Fr.; *Salzsäure*, Germ.) This acid is now extracted from sea-salt, by the action of sulphuric acid and a moderate heat; but it was originally obtained from the salt by exposing a mixture of it and of common clay to ignition in an earthen retort. The acid gas which exhales is rapidly condensed by water. 100 cubic inches of water are capable of absorbing no less than 48,000 cubic inches of the acid gas, whereby the liquid acquires a specific gravity of 1·2109: and a volume of 142 cubic inches. This vast condensation is accompanied with a great production of heat, whence it becomes necessary to apply artificial refrigeration, especially if so strong an acid as the above is to be prepared. In general, the muriatic acid of commerce has a specific gravity varying from 1·15 to 1·20; and contains, for the most part, considerably less than 40 parts by weight of acid gas in the hundred. The above stronger acid contains 42·68 per cent. by weight; for since a cubic inch of water, which weighs 252·5 grains, has absorbed 480 cubic inches = 188 grains of gas; and $252·5 + 188 = 440·5$; then $440·5 : 188 :: 100 : 42·68$. In general a very good approximation may be found to the percentage of real muriatic acid, in any liquid sample, by multiplying the decimal figures of the specific gravity by 200. Thus for example, at 1·162 we shall have by this rule $0·162 \times 200 = 32·4$, for the quantity of gas in 100 parts of the liquid. Muriatic acid gas consists of chlorine and hydrogen combined, without condensation, in equal volumes. Its specific gravity is 1·247, air = 1·000.

By sealing up muriate of ammonia and sulphuric acid, apart, in a strong glass tube reversed, and then causing them to act on each other, Sir H. Davy procured liquid muriatic acid. He justly observes, that the generation of elastic substances in close vessels, either with or without heat, offers much more powerful means of approximating their molecules than those dependent on the application of cold, whether natural or artificial; for as gases diminished only $\frac{1}{400}$ in volume for every degree of Fahrenheit's scale, beginning at ordinary temperatures, a very slight condensation only can be produced by the most powerful freezing mixtures, not half so much as would result from the application of a strong flame to one part of a glass tube, the other part being of ordinary temperature; and when attempts are made to condense gases into liquids by sudden mechanical compression, the heat instantly generated presents a formidable obstacle to the success of the experiment; whereas in the compression resulting from their slow generation in close vessels, if the process be conducted with common precautions, there is no source of difficulty or danger; and it may be easily assisted by artificial cold, in cases where gases approach near to that point of compression and temperature at which they become vapours. — *Phil. Trans.* 1823.

The muriatic acid of commerce has usually a yellowish tinge, but when chemically pure it is colourless. It fumes strongly in the air, emitting a corrosive vapour of a peculiar smell. The characteristic test of muriatic acid in the most dilute state, is nitrate of silver, which causes a curdy precipitate of chloride of silver.

The preparation of this acid upon the great scale is frequently effected in this country

by acting upon sea-salt in hemispherical iron pots, or in cast-iron cylinders, with concentrated sulphuric acid; taking 6 parts of the salt to 5 of the acid. The mouth of the pot may be covered with a slab of siliceous freestone, perforated with two holes of about two inches in diameter each, into the one of which the acid is poured by a funnel in successive portions, and into the other, a bent glass, or stone-ware tube, is fixed, for conducting the disengaged muriatic gas into a series of large globes of bottle glass, one-third filled with water, and laid on a sloping sand-bed. A week is commonly employed for working off each pot; no heat being applied to it till the second day.

The decomposition of sea-salt by sulphuric acid was at one time carried on by some French manufacturers in large leaden pans, 10 feet long, 5 feet broad, and a foot deep, covered with sheets of lead, and luted. The disengaged acid gas was made to circulate in a conduit of glazed bricks, nearly 650 yards long, where it was condensed by a sheet of water exceedingly thin, which flowed slowly in the opposite direction of the gas down a slope of 1 in 200. At the end of this canal nearest the apparatus, the muriatic acid was as strong as possible, and pretty pure; but towards the other end, the water was hardly acidulous. The condensing part of this apparatus was therefore tolerably complete; but as the decomposition of the salt could not be finished in the leaden pans, the acid mixture had to be drawn out of them, in order to be completely decomposed in a reverberatory furnace; in this way nearly 50 per cent. of the muriatic acid was lost. And besides, the great quantity of gas given off during the emptying of the lead-chambers was apt to suffocate the workmen, or seriously injured their lungs, causing severe hemoptysis. The employment of muriatic acid is so inconsiderable, and the loss of it incurred in the preceding process is of so little consequence, that subsequently, both in France and in England, sulphate of soda, for the soda manufacture, has been procured with the dissipation of the muriatic acid in the air. In the method more lately resorted to, the gaseous products are discharged into extensive vaults, where currents of water condense them and carry them off into the river. The surrounding vegetation is thereby saved in some measure from being burned up, an accident which was previously sure to happen when fogs precipitated the floating gases upon the ground. At Newcastle, Liverpool, and Marseilles, where the consumption of muriatic acid bears no proportion to the manufacture of soda, this process is now practised upon a vast scale.

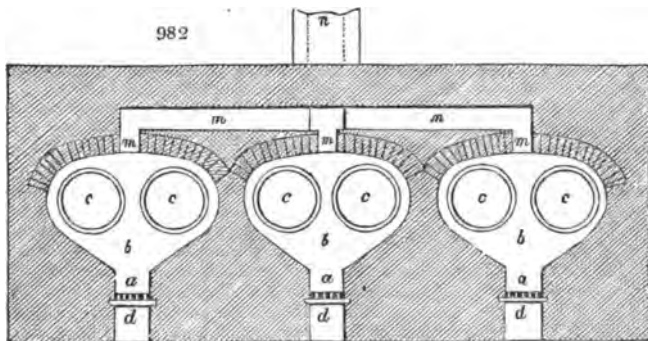
The apparatus for condensing muriatic acid gas has been modified and changed, of late years, in many different ways.

The Bastringue apparatus. At the end of a reverberatory furnace, (see *CORRZA, SMELTING OF, and SODA, MANUFACTURE OF,*) a rectangular lead trough or pan, about 1 foot deep, of a width equal to that of the interior of the furnace, that is about 5 feet wide, and 6½ feet long, is encased in masonry, having its upper edges covered with cast-iron plates or fire tiles, and placed upon a level with the passage of the flame, as it escapes from the reverberatory. The arch which covers that pan forms a continuation of the roof of the reverberatory, and is of the same height. The flame which proceeds from the furnace containing the mixture of salt and sulphuric acid is made to escape between the vault and the surface of the iron plates or fire tiles, through a passage only 4 inches in height. When the burned air and vapours reach the extremity of the pan, they are reflected downwards, and made to return beneath the bottom of the pan, in a flue, which is afterwards divided so as to lead the smoke into two lateral flues, which terminate in the chimney. The pan is thus surrounded as it were with the heat and flame discharged from the reverberatory furnace. See *EVAPORATION*. A door is opened near the end of the pan, for introducing the charge of sea-salt, amounting to 12 bags of 2 cwt. each, or 24 cwt. This door is then luted on as tightly as possible, and for every 100 parts of salt, 110 of sulphuric acid are poured in, of specific gravity 1.594, containing 57 per cent. of dry acid. This acid is introduced through a funnel inserted in the roof of the furnace. Decomposition ensues, muriatic acid gas mingled with steam is disengaged, and is conducted through 4 stone-ware tubes into the refrigerators, where it is finally condensed. These refrigerators consist of large stone-ware carboys, called *dame-jeans* in France, to the number of 7 or 8 for each pipe, and arranged so that the neck of the one communicates with the body of the other: thus the gas must traverse the whole series, and gets in a good measure condensed by the water in them, before reaching the last.

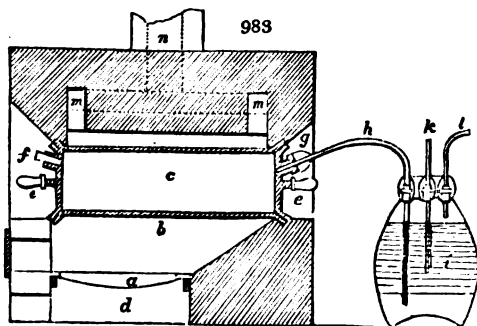
When the operation is finished, the door opposite the pan is opened, and the residuum in it is discharged, in the form of a fluid magma, upon a square bed of bricks, exterior to the furnace. This paste speedily concretes on cooling, and is then broken into fragments and carried to the soda manufactory. The immense quantity of gas exhaled in discharging the pan, renders this part of the operation very painful to the workmen; and wasteful in reference to the production of muriatic acid. The difficulty of luting securely the cast-iron plates or fire tiles which cover the pan, the impossibility of completing the decomposition of the salt, since the residuum must be run off in a liquid state, finally, the damage sustained by the melting and corrosion of the lead, &c., are among the causes why no more than 80 or 90 parts of muriatic acid at 1.170 are collected,

equivalent to 25 per cent. of real acid for every 100 of salt employed, instead of much more than double that quantity, which it may be made to yield by a well conducted chemical process.

The *cylinder apparatus* is now much esteemed by many manufacturers. *Fig. 982.* represents, in transverse section, a bench of iron cylinder retorts, as built up in a proper furnace for producing muriatic acid; and *fig. 983.* a longitudinal section of one retort



with one of its carboys of condensation. *a* is the grate; *b*, a fireplace, in which two iron cylinders, *c c*, are set alongside of each other. They are $5\frac{1}{2}$ feet long, 20 inches in diameter, about $\frac{1}{4}$ of an inch thick, and take 1.6 cwts. of salt for a charge; *d* is the ash-pit; *e, e*, are cast-iron lids for closing both ends of the cylinders; *f* is a tube in the posterior lid, for pouring in the sulphuric acid; *g* is another tube, in the anterior lid, for the insertion of the bent pipe of hard glazed stone-ware *h*; *i*, is a three-necked stone-ware carboy; *k* is a tube of safety; *l*, a tube of communication with the second carboy; *m m, m m*, are the flues leading to the chimney *n*.



After the salt has been introduced, and the fire kindled, 83 $\frac{1}{2}$ per cent. of its weight of sulphuric acid, of spec. grav. 1.80, should be slowly poured into the cylinder through a lead funnel, with a syphon-formed pipe. The three-necked carboys may be either placed in a series for each retort, like a range of Woulfe's bottles, or all the carboys of the front range may be placed in communication with one another, while the last carboy at one end is joined to the first of the second range; and thus in succession. They must be half filled with cold water; and when convenient, those of the front row at least, should be plunged in an oblong trough of running water. The acid which condenses in the carboys of that row is apt to be somewhat contaminated with sulphuric acid, muriate of iron, or even sulphate of soda; but that in the second and third will be found to be pure. In this way 100 parts of sea-salt will yield 130 parts of muriatic acid, of spec. grav. 1.19; while the sulphate of soda in the retort will afford from 208 to 210 of that salt in crystals.

It is proper to heat all the parts of the cylinders equally, to insure the simultaneous decomposition of the salt, and to protect it from the acid; for the hotter the iron, and the stronger the acid, the less erosion ensues.

Some manufacturers, with the view of saving fuel by the construction of their furnaces, oppose to the flame as many obstacles as they can, and make it perform numerous circulations round the cylinders; but this system is bad, and does not even effect the desired economy, because the passages, being narrow, impair the draft, and become speedily choked up with the soot, which would be burned profitably in a freer space; the decomposition also, being unequally performed, is less perfect, and the cylinders are more injured. It is better to make the flame envelope at once the body of the cylinder;

after which it may circulate beneath the vault, in order to give out a portion of its caloric before it escapes at the chimney.

The fire should be briskly kindled, but lowered as soon as the distillation commences; and then continued moderate till the evolution of gas diminishes, when it must be heated somewhat strongly to finish the decomposition. The iron door is now removed, to extract the sulphate of soda, and to recommence another operation. This sulphate ought to be white and uniform, exhibiting in its fracture no undecomposed sea-salt.

Liquid muriatic acid has a very sour corrosive taste, a pungent suffocating smell, and acts very powerfully upon a vast number of mineral, vegetable, and animal substances. It is much employed for making many metallic solutions; and in combination with nitric acid, it forms the aqua regia of the alchemists, so called from its property of dissolving gold.

Table of Muriatic Acid, by Dr. Ure.

| Acid of 120 in 100. | Specific Gravity. | Chlorine. | Muriatic Gas. | Acid of 120 in 100. | Specific Gravity. | Chlorine. | Muriatic Gas. | Acid of 120 in 100. | Specific Gravity. | Chlorine. | Muriatic Gas. |
|---------------------|-------------------|-----------|---------------|---------------------|-------------------|-----------|---------------|---------------------|-------------------|-----------|---------------|
| 100 | 1.2000 | 39.675 | 40.777 | 66 | 1.1328 | 26.186 | 26.913 | 32 | 1.0637 | 12.697 | 13.049 |
| 99 | 1.1982 | 39.278 | 40.369 | 65 | 1.1308 | 25.789 | 26.505 | 31 | 1.0617 | 12.300 | 12.641 |
| 98 | 1.1964 | 38.882 | 39.961 | 64 | 1.1287 | 25.392 | 26.098 | 30 | 1.0597 | 11.903 | 12.233 |
| 97 | 1.1946 | 38.485 | 39.554 | 63 | 1.1267 | 24.996 | 25.690 | 29 | 1.0577 | 11.506 | 11.825 |
| 96 | 1.1928 | 38.089 | 39.146 | 62 | 1.1247 | 24.599 | 25.282 | 28 | 1.0557 | 11.109 | 11.418 |
| 95 | 1.1910 | 37.692 | 38.738 | 61 | 1.1226 | 24.202 | 24.874 | 27 | 1.0537 | 10.712 | 11.010 |
| 94 | 1.1893 | 37.296 | 38.330 | 60 | 1.1206 | 23.805 | 24.466 | 26 | 1.0517 | 10.316 | 10.602 |
| 93 | 1.1875 | 36.900 | 37.923 | 59 | 1.1185 | 23.408 | 24.058 | 25 | 1.0497 | 9.919 | 10.194 |
| 92 | 1.1857 | 36.503 | 37.516 | 58 | 1.1164 | 23.012 | 23.650 | 24 | 1.0477 | 9.522 | 9.786 |
| 91 | 1.1846 | 36.107 | 37.108 | 57 | 1.1143 | 22.615 | 23.242 | 23 | 1.0457 | 9.125 | 9.379 |
| 90 | 1.1822 | 35.707 | 36.700 | 56 | 1.1123 | 22.218 | 22.834 | 22 | 1.0437 | 8.729 | 8.971 |
| 89 | 1.1802 | 35.310 | 36.292 | 55 | 1.1102 | 21.822 | 22.426 | 21 | 1.0417 | 8.332 | 8.563 |
| 88 | 1.1782 | 34.913 | 35.884 | 54 | 1.1082 | 21.425 | 22.019 | 20 | 1.0397 | 7.935 | 8.155 |
| 87 | 1.1762 | 34.517 | 35.476 | 53 | 1.1061 | 21.028 | 21.611 | 19 | 1.0377 | 7.538 | 7.747 |
| 86 | 1.1741 | 34.121 | 35.068 | 52 | 1.1041 | 20.632 | 21.203 | 18 | 1.0357 | 7.141 | 7.340 |
| 85 | 1.1721 | 33.724 | 34.660 | 51 | 1.1020 | 20.235 | 20.796 | 17 | 1.0337 | 6.745 | 6.932 |
| 84 | 1.1701 | 33.328 | 34.252 | 50 | 1.1000 | 19.837 | 20.388 | 16 | 1.0318 | 6.348 | 6.524 |
| 83 | 1.1681 | 32.931 | 33.845 | 49 | 1.0980 | 19.440 | 19.980 | 15 | 1.0298 | 5.951 | 6.116 |
| 82 | 1.1661 | 32.535 | 33.437 | 48 | 1.0960 | 19.044 | 19.572 | 14 | 1.0279 | 5.554 | 5.709 |
| 81 | 1.1641 | 32.136 | 33.029 | 47 | 1.0939 | 18.647 | 19.165 | 13 | 1.0259 | 5.158 | 5.301 |
| 80 | 1.1620 | 31.743 | 32.621 | 46 | 1.0919 | 18.250 | 18.757 | 12 | 1.0239 | 4.762 | 4.893 |
| 79 | 1.1599 | 31.343 | 32.213 | 45 | 1.0899 | 17.854 | 18.350 | 11 | 1.0220 | 4.365 | 4.486 |
| 78 | 1.1578 | 30.946 | 31.805 | 44 | 1.0879 | 17.457 | 17.941 | 10 | 1.0200 | 3.968 | 4.078 |
| 77 | 1.1557 | 30.550 | 31.398 | 43 | 1.0859 | 17.060 | 17.534 | 9 | 1.0180 | 3.571 | 3.670 |
| 76 | 1.1536 | 30.153 | 30.990 | 42 | 1.0838 | 16.664 | 17.126 | 8 | 1.0160 | 3.174 | 3.262 |
| 75 | 1.1515 | 29.757 | 30.582 | 41 | 1.0818 | 16.267 | 16.718 | 7 | 1.0140 | 2.778 | 2.854 |
| 74 | 1.1494 | 29.361 | 30.174 | 40 | 1.0798 | 15.870 | 16.310 | 6 | 1.0120 | 2.381 | 2.447 |
| 73 | 1.1473 | 28.964 | 29.767 | 39 | 1.0778 | 15.474 | 15.902 | 5 | 1.0100 | 1.984 | 2.039 |
| 72 | 1.1452 | 28.567 | 29.359 | 38 | 1.0758 | 15.077 | 15.494 | 4 | 1.0080 | 1.588 | 1.631 |
| 71 | 1.1431 | 28.171 | 28.951 | 37 | 1.0738 | 14.680 | 15.087 | 3 | 1.0060 | 1.191 | 1.224 |
| 70 | 1.1410 | 27.774 | 28.544 | 36 | 1.0718 | 14.284 | 14.679 | 2 | 1.0040 | 0.795 | 0.816 |
| 69 | 1.1389 | 27.376 | 28.136 | 35 | 1.0697 | 13.887 | 14.271 | 1 | 1.0020 | 0.397 | 0.408 |
| 68 | 1.1369 | 26.979 | 27.728 | 34 | 1.0677 | 13.490 | 13.863 | | | | |
| 67 | 1.1349 | 26.583 | 27.321 | 33 | 1.0657 | 13.094 | 13.456 | | | | |

In treating of soda, we shall have occasion to comment upon the formation of muriatic acid; and therefore it is unnecessary to enter into the details of that operation here. The purest commercial muriatic acid commonly contains sulphureous acid in considerable quantity, which unfits it for many purposes, and ought therefore to be guarded against; but more than this, when made from sulphuric acid containing arsenic, it is invariably contaminated with that poisonous substance, and hence, those persons who are in the habit of making what is called digestive bread, by an admixture of bicarbonate of soda and muriatic acid with the flour they employ, cannot be too careful in going to none but the most respectable sources for their acid; as an enormous amount of rough muriatic acid is constantly passing through the market positively loaded with arsenious impurity. For the same reason, as chloride of lime is manufactured from the acid, it must be regarded with a cautious eye; as, during the action of such muriatic acid upon peroxide of manganese, a highly volatile chloride of arsenic

passes off with the chlorine gas, and is condensed like it by the lime. Since, however, this, in the end, becomes arsenite of lime, a salt almost insoluble in water, the tendency to mischief is greatly diminished. Nevertheless, as in some medico-legal works it is recommended to sprinkle cadaverous exhumations with chloride of lime, the ends of justice may easily be perverted or prevented, if due care be not employed to ascertain beforehand that the chloride of lime is pure. Very little indeed of that to be met with in commerce will bear a careful analytical investigation.

MURIATES were, till the great chemical era of Sir H. Davy's researches upon chlorine, considered to be compounds of an undecomposed acid, the muriatic, with the different bases; but he proved them to be in reality compounds of chlorine with the metals. They are all, however, still known in commerce by their former appellation. The only muriates much used in the manufactures are, *Muriate of ammonia* or SAL-AMMONIAC; *muriated peroxide of mercury*, MERCURY, bichloride of; *muriate of soda*, or chloride of sodium, see SALT; *muriate of tin*, see CALICO-PRINTING and TIN; *Submuriate of mercury* or CALOMEL.

MUSK (*Musc*, Fr.; *Moschus*, Germ.), is a peculiar aromatic substance, found in a sac between the navel and the parts of generation of a small male quadruped of the deer kind, called by Linnaeus *Moschus moschiferus*, which inhabits Tonquin and Thibet. The colour of musk is blackish-brown; it is lumpy or granular, somewhat like dried blood, with which substance, indeed, it is often adulterated. The intensity of its smell is almost the only criterion of its genuineness. When thoroughly dried it becomes nearly scentless; but it recovers its odour when slightly moistened with water of ammonia. The Tonquin musk is most esteemed. It comes to us in small bags covered with a reddish-brown hair; the bag of the Thibet musk is covered with a silver-gray hair. All the analyses of musk hitherto made teach little or nothing concerning its active or essential constituent. It is used in medicines, and is an ingredient in a great many perfumes.

The musk deer, from the male of which animal species the bag containing this valuable drug is obtained, is a native of the mountainous Kirgesean and Langorian steps of the Altai, on the river Irtysh, extending eastwards as far as the river Jenisei and Lake Baikal; and generally of the mountains of Eastern Asia, between 90° and 60° of N. Lat. Two distinct kinds of musk are known in commerce, the first being the Chinese Tonquin, Thibetian or Oriental, and the Siberian or Russian. The Chinese is regarded by Dr. Goebel as the result of ingenious adulterations of the genuine article by that crafty people. The Russian musk is genuine, the bags never being opened, are consequently never sewn, nor artificially closed, like those imported into London from China. The former is sometimes so fresh, that moisture may be expressed from the bag by cutting through its fleshy side. The interior mass is frequently of a soft and pappy consistence; but the surface of the bag is perfectly dry. The Chinese bags are found invariably to have been opened and again glued together, more or less neatly; though sometimes the stitches of the sewing are manifest. Mr. Dyrssen, an eminent merchant at St. Petersburg, states that during the many years he has been in the trade, although he has received at a time from 100 to 200 ounces from London, yet in no case whatever has he met with a bag which had not been opened, and closed with more or less ingenuity. The genuine contents seem to have been first removed, modified, and replaced. M. Guibourt gives the following as the constituents of a Chinese musk bag: 1. water; 2. ammonia; 3. solid fat or stearine; 4. liquid fat or elaine; 5. cholesterine; 6. acid oil, combined with ammonia; 7. volatile oil; 8—10. hydrochlorates of ammonia, potassa, and lime; 11. an undetermined acid; 12. gelatine; 13. albumen; 14. fibrine; 15. carbonaceous matter soluble in water; 16. calcareous salt; 17. carbonate of lime; 18. hairs and sand.

From June 1841 to June 1842, a duty of 6*d.* per oz. was paid at the port of London alone upon 969 ounces of musk. The prices of grain musk of the best quality (the matter without the bag) varies from 60*s.* to 95*s.* per oz.

There is a superior musk imported now from the United States, which is nearly free from the carbonate of lime, so abundant in the bags of the Siberian musk.

MUSLIN, is a fine cotton fabric, used for ladies' robes; which is worn either white, dyed, or printed.

MUSQUET. It is now twenty-two years since the Hon. Board of Ordnance, with the view of introducing the use of percussion fire-arms into the British Army, employed me to investigate experimentally the best mode of preparing the priming powder for that purpose. The result of these experiments was presented in a report, the substance of which is given under the article *FULMINANTS* in this Dictionary. During this long interval, Mr. Lovell, inspector of small arms for her Majesty's service, and director of the Royal manufactory, at Enfield Chase, has directed his ingenious mind to the construction of a sure, simple, and strong musquet, with which, under his able superintendance, the whole of her Majesty's soldiers are now provided. He has also

furnished them with a short, but clear set of instructions for the cleaning and management of these excellent arms, illustrated by a series of wood engravings. From this little work the following notice is copied.

Fig. 984. The barrel, reduced to one-seventh size. *a*, the breech; *b*, the nipple-seat or lump; *c*, the back-sight; *d*, the back loop; *e*, the middle loop; *f*, the swivel-loop; *g*, the front-loop with the bayonet-spring attached; *h*, the front sight; *i*, the muzzle.

Fig. 985. The breech-pin, half size. *a*, the tang; *b*, the neck; *c*, the screw-threads; *d*, the face.

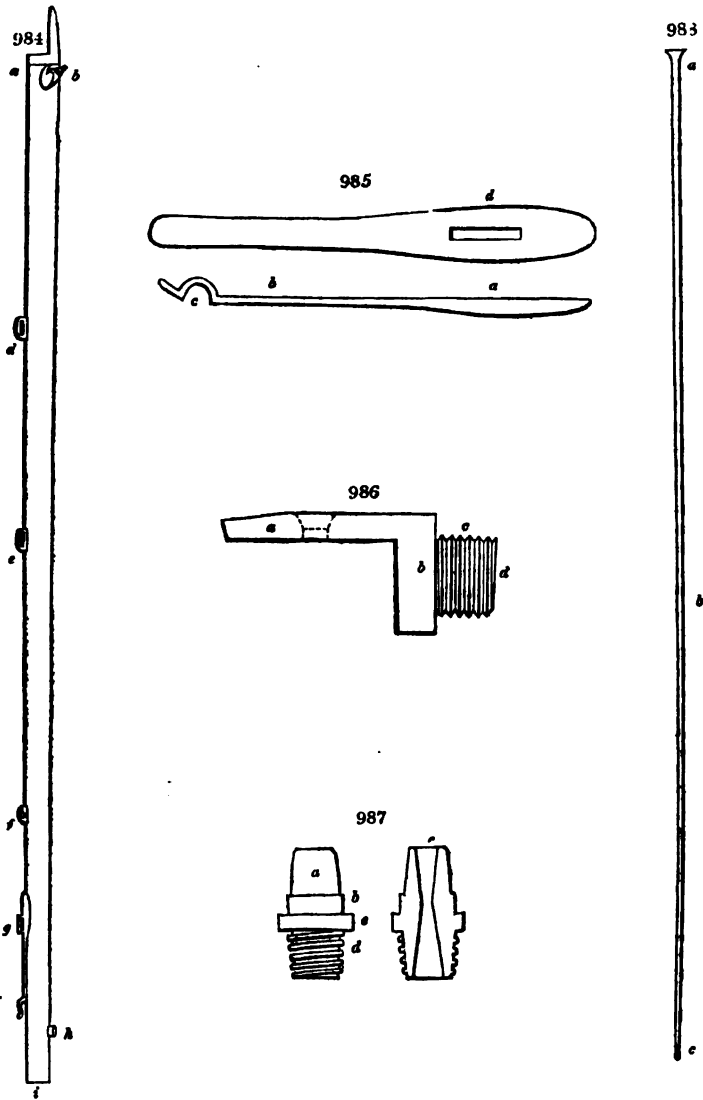


Fig. 986. The bayonet-spring, two ways, half size. *a*, the shank; *b*, the neck; *c*, the hook; *d*, the mortice.

Fig. 987. The nipple, full size. *a*, the cone; *b*, the squares; *c*, the shoulder; *d*, the screw-threads; *e*, the touch-hole.

Fig. 988. The rammer, reduced to one-seventh size. *a*, the head; *b*, the shaft; *c* the screw-threads.

Fig. 989. The lock outside, half size. *a*, the plate; *b*, the cock; *c*, the tumbler-pin; *d*, the hollow for the nipple seat.

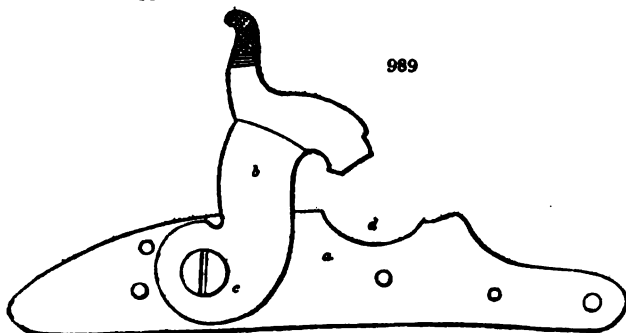
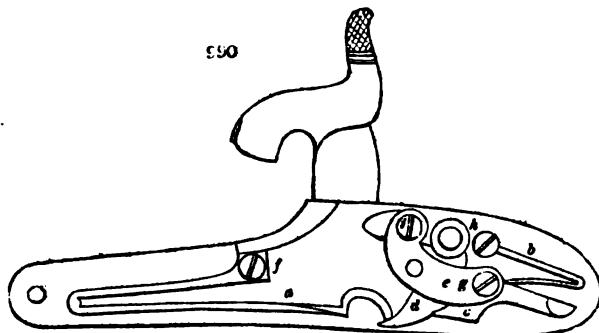


Fig. 990. The lock, inside, half size, showing all the parts in their places with the cock down at bearer. *a*, the main-spring; *b*, the sear-spring; *c*, the sear; *d*, the tumbler;



e, the bridle; *f* the main-spring-pin; *g*, the sear-pin; *h*, the sear-spring-pin; *i*, the bridle-pin.

MUST, is the sweet juice of the grape.

MUSTARD (*Mustarde*, Fr.; *Senf*, Germ.); is a plant which yields the well-known seed used as a condiment to food. M. Lenormand gives the following prescription for preparing mustard for the table.

With 2 pounds of very fine flour of mustard, mix half an ounce of each of the following fresh plants; parsley, chervil, celery, and tarragon, along with a clove of garlic, and twelve salt anchovies, all well minced. The whole is to be triturated with the flour of mustard till the mixture becomes uniform. A little grape-must or sugar is to be added to give the requisite sweetness; then one ounce of salt, with sufficient water to form a thinnish paste by rubbing in a mortar. With this paste the mustard pots being nearly filled, a red-hot poker is to be thrust down into the contents of each, which removes (it is said) some of the acrimony of the mustard, and evaporates a little water, so as to make room for pouring a little vinegar upon the surface of the paste. Such table mustard not only keeps perfectly well, but improves with age.

The mode of preparing table mustard patented by M. Soyés, consisted in steeping mustard seed in twice its bulk of weak wood vinegar for eight days, then grinding the whole into paste in a mill, putting it into pots, and thrusting a red-hot poker into each of them.

MUTAGE, is a process used in the south of France to arrest the progress of fermentation in the must of the grape. It consists either in diffusing sulphurous acid, from burning sulphur matches in the cask containing the must, or in adding a little sulphite (not sulphate) of lime to it. The last is the best process. See FERMENTATION.

MYRICINE, is a vegetable principle which constitutes from 20 to 30 per cent. of the weight of bees-wax, being the residuum from the solvent action of alcohol upon that

substance. It is a greyish-white solid, which may be vaporized almost without alteration.

MYRRH, is a gum-resin, which occurs in tears of different sizes; they are reddish-brown, semi-transparent, brittle, of a shining fracture, appear as if greasy under the pebble, they have a very acrid and bitter taste, and a strong, not disagreeable, smell. Myrrh flows from the incisions of a tree not well known, which grows in Arabia and Abyssinia, supposed to be a species of *amyris* or *mimosæ*. It consists of resin and gum in proportions stated by Pelletier at 31 of the former and 66 of the latter; but by Bracconot, at 23 and 77. It is used only in medicine.

N.

NACARAT, is a term derived from the Spanish word *sacar*, which signifies mother of pearl; and is applied to a pale red colour, with an orange cast. See CALICO-PRINTING. The *nacar* of Portugal or *Bezetta* is a crape or fine linen fabric, dyed fugitively of the above tint, which ladies rub upon their countenances to give them a roseate hue. The Turks of Constantinople manufacture the brightest red crapes of this kind. See ROUZE.

NAILS, MANUFACTURE OF. (*Clow*, Fr.; *Nagel*, Germ.)

The forging of nails was till of late years a handicraft operation, and therefore belonged to a book of trades rather than to a dictionary of arts. But several combinations of machinery have been recently employed, under the protection of patents, for making these useful implements, with little or no aid of the human hand; and these deserve to be noticed, on account both of their ingenuity and importance.

As nails are objects of prodigious consumption in building their block-houses, the citizens of the United States very early turned their mechanical genius to good account in the construction of various machines for making them. So long since as the year 1810, it appears, from the report of the secretary of their treasury, that they possessed a machine which performed the cutting and heading at one operation, with such rapidity that it could turn out upwards of 100 nails per minute. "Twenty years ago," says the secretary of the state of Massachusetts, in that report, "some men, then unknown, and then in obscurity, began by cutting slices out of old hoops, and, by a common vice gripping these pieces, headed them with several strokes of the hammer. By progressive improvements slitting-mills were built, and the shears and the heading tools were perfected; yet much labour and expense were requisite to make nails. In a little time Jacob Perkins, Jonathan Ellis, and a few others, put into execution the thought of cutting and of heading nails by water power; but, being more intent upon their machinery than upon their pecuniary affairs, they were unable to prosecute the business. At different times other men have spent fortunes in improvements, and it may be said with truth that more than one million of dollars has been expended; but at length these joint efforts are crowned with complete success, and we are now able to manufacture, at about one-third of the expense that wrought nails can be manufactured for, nails which are superior to them for at least three-fourths of the purposes to which nails are applied, and for most of those purposes they are full as good. The machines made use of by Ordiorne, those invented by Jonathan Ellis, and a few others, present very fine specimens of American genius.

"To northern carpenters, it is well known that in almost all instances it is unnecessary to bore a hole before driving a cut nail; all that is requisite is, to place the cutting edge of the nail across the grain of the wood; it is also true, that cut nails will hold better in the wood. These qualities are, in some rough building works, worth twenty per cent. of the value of the article, which is equal to the whole expense of manufacturing. For sheathing and drawing, cut nails are full as good as wrought nails; only in one respect are the best wrought nails a little superior to cut nails, and that is where it is necessary they should be clenched. The manufacture of cut nails was born in our country, and has advanced, within its bosom, through all the various stages of infancy to manhood; and no doubt we shall soon be able, by receiving proper encouragement, to render them superior to wrought nails in every particular.

"The principal business of rolling and slitting-mills, is rolling nail plates; they also serve to make nail rods, hoops, tires, sheet iron, and sheet copper. In this State we have not less than twelve.

"These mills could roll and slit 7000 tons of iron a year; they now, it is presumed, roll and slit each year about 3500 tons, 2400 tons of which, probably, are cut up into nails and brads, of such a quality that they are good substitutes for hammered nails, and in fact, have the preference with most people, for the following reasons; viz., on account of the sharp corner and true taper with which cut nails are formed; they may be driven into harder wood without bending or breaking, or hazard of splitting the wood, by

which the labour of boring is saved, the nail one way being of the same breadth or thickness from head to point."— *American Journal*.

Since the year 1820, the following patents have been obtained in England for making nails; many of them of American origin:—

Alexander Law, September, 1821, for nails and bolts for ships' fastenings, made in a twisted form, by hand labour.

Glascott & Mitchell, December, 1823, for ship nails with rounded heads, by hand labour.

Wilks & Ecroyd, November, 1825, for an engine for cutting wedge-form pieces from plates.

Leddom & Jones, December 11, 1827, for machinery for cutting brads and sprigs from plates; it does not form heads.

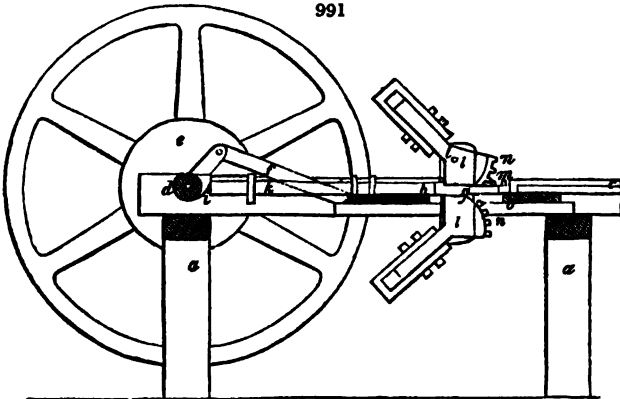
The first nail apparatus to which I shall particularly advert, is due to Dr. Church; it was patented in his absence by his correspondent, Mr. Thomas Tyndall, of Birmingham, in December, 1827. It consists of two parts; the first is a mode of forming nails, and the shafts of screws, by pinching or pressing ignited rods of iron between indented rollers; the second produces the threads on the shafts of the screws previously pressed. The metallic rods, by being passed between a pair of rollers, are rudely shaped, and then cut asunder between a pair of shears; after which they are pointed and headed, or otherwise brought to their finished forms, by the agency of dies placed in a revolving cylinder. The several parts of the mechanism are worked by toothed wheels, cams, and levers. The second part of Dr. Church's invention consists of a mechanism for cutting the threads of screws to any degree of obliquity or form.*

Mr. L. W. Wright's (American) apparatus should have been mentioned before the preceding, as the patent for it was sealed in March of the same year; though an amended patent was obtained in September, 1828. Its object was to form metal screws for wood. I have seen the machinery, but consider it much too complex to be described in the present work.

Mr. Edward Hancorne, of Skinner-street, London, nail manufacturer, obtained a patent in October, 1828, for a nail-making machine, of which a brief description may give my readers a conception of this kind of manufacture. Its principles are similar to those of Dr. Church's more elaborate apparatus.

The rods or bars having been prepared in the usual way, either by rolling or hammering, or by cutting from sheets or plates of iron, called slitting, are then to be made redhot, and in that state passed through the following machine, whereby they are at once cut into suitable lengths, pressed into wedge forms for pointing at the one end, and stamped at the other end to produce the head. A longitudinal view of the machine is shown in *fig. 991*. A strong iron frame-work, of which one side is shown at *a*, supports the whole of the mechanism. *b* is a table capable of sliding to and fro horizontally. Upon this table are the clamps, which lay hold of the sides of the rod as it advances; as also the shears which cut the rod into nail lengths.

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These clamps or holders consist of a fixed piece and a movable piece; the latter being brought into action by a lever. The rod or bar of iron shown at *c*, having been made redhot, is introduced into the machine by sliding it forward upon the table *b*, when the table is in its most advanced position; rotatory motion is then given to the

* For further details, see *Newton's Journal*, 2nd series, vol. iii. p. 184.

crank shaft *d*, by means of a band passing round the rigger pulley *e*, which causes the table *b* to be drawn back by the crank rod *f*; and as the table recedes, the horizontal lever is acted upon, which closes the clamps. By these means the clamps take fast hold of the sides of the heated rod, and draw it forward, when the movable chap of the shears, also acted upon by a lever, slides laterally, and cuts off the end of the rod held by the clamps; the piece thus separated is destined to form one nail.

Suppose that the nail placed at *g*, having been thus brought into the machine and cut off, is held between clamps, which press it sideways (these clamps are not visible in this view); in this state it is ready to be headed and pointed.

The *header* is a steel die *h*, which is to be pressed up against the end of the nail by a cam *i*, upon the crank-shaft; which cam, at this period of the operation, acts against the end of a rod *k*, forming a continuation of the die *h*, and forces up the die, thus compressing the metal into the shape of a nail-head.

The *pointing* is performed by two rolling snail pieces or spirals *l, l*. These pieces are somewhat broader than the breadth of the nail; they turn upon axles in the side frames. As the table *b* advances, the racks *m*, on the edge of this table, take into the toothed segments *n, n*, upon the axles of the spirals, and cause them to turn round.

These spirals pinch the nail at first close under its head with very little force; but as they turn round, the longer radius of the spiral comes into operation upon the nail, so as to press its substance very strongly, and squeeze it into a wedge form. Thus the nail is completed, and is immediately discharged from the clamps or holders. The carriage is then moved again by the rotation of the crank-shaft, which brings another portion of the rod *c* forward, cuts it off, and then forms it into a nail.

Richard Prosser, July, 1831, for making tacks for ornamental furniture, by soldering or wedging the spike into the head. This also is the invention of Dr. Church.

Dr. William Church, February, 1832, for improvements in machinery for making nails. These consist, first, in apparatus for forming rods, bars, or plates of iron, or other metals; secondly, in apparatus for converting the rods, &c., into nails; thirdly, in improvements upon Prosser's patent. The machinery consists in laminating rollers, and compressing dies.

The method of forming the rods from which the nails are to be made, is very advantageous. It consists in passing the bar or plate iron through pressing rollers, which have indentations upon the peripheries of one or both of them, so as to form the bar or plate into the required shape for the rods, which may be afterwards separated into rods of any desired breadth, by common slitting rollers.

The principal object of rolling the rods into these wedge forms, is to measure out a quantity of metal duly proportioned to the required thickness or strength of the nail in its several parts; which quantity corresponds to the indentations of the rollers.

Thomas John Fuller, February 27, 1834, for an improved apparatus for making square-pointed, and also flat-pointed nails. He claims as his invention, the application of vertical and horizontal hammers (mounted in his machine) combined for the purpose of tapering and forming the points of the nails; which, being made to act alternately, resemble hand work, and are therefore not so apt to injure the fibrous texture of the iron, he imagines, as the rolling machinery is. He finishes the points by rollers.

Miles Berry, February 19, 1834, for machinery for forming metal into bolts, rivets, nails and other articles; being a communication from a foreigner residing abroad. He employs in his machine holding chaps, heading dies, toggle joints, cams, &c., mechanisms apparently skilfully contrived, but too complex for admission under the article *nail* in this volume.

William Southwood Stocker, July, 1836. This is a machine apparently of American parentage, as it has the same set of features as the old American mechanisms of Perkins & Dyer, at the Britannia Nail Works, Birmingham, and all the other American machines since described, for pressing metal into the forms of nails, pins, screw-shafts, rivets, &c.; for example, it possesses pressers or hammers for squeezing the rods of metal and forming the shanks, which are all worked by a rotatory action; cutters for separating the appropriate lengths, and dies for forming the heads by compression, also actuated by revolving cams or cranks.

Mr. Stocker intends, in fact, to effect the same sorts of operations by automatic mechanisms as are usually performed by the hands of a nail-maker with his hammer and anvil; viz., the shaping of a nail from a heated rod of iron, cutting it off at the proper length, and then compressing the end of the metal into the form of the head. His machine may be said to consist of two parts, connected in the same frame; the one for shaping the shank of the nail, the other for cutting it off and heading it. The frame consists of a strong table to bear the machinery. Two pairs of hammers, formed as levers, the one pair made to approach each other by horizontal movements, the other pair by vertical movements, are the implements by which a portion at the end of a red-hot rod of iron is beaten or pressed into the wedge-like shape of the shaft of a nail. This having been

done, and the rod being still hot, is withdrawn from the beaters, and placed in the other part of the machine, consisting of a pair of jaws like those of a vice, which pinch the shank of the nail and hold it fast. A cutter upon the side of a wheel now comes round, and, by acting as the moving chap of a pair of shears, cuts the nail off from the rod. The nail shank being still firmly held in the jaws of the vice, with a portion of its end projecting outwardly, the heading die is slidden laterally until it comes opposite to the end of the nail; the dye is then projected forward with great force, for the purpose of what is termed upsetting the metal at the projecting end of the nail, and thereby blocking out the head.

A main shaft, driven by a band and rigger as usual, brings, as it revolves, a cam into operation upon a lever which carries a double inclined plane or wedge in its front or acting part. This wedge being by the rotatory cam projected forwards between the tails of one of the pairs of hammers, causes the faces of these hammers to approach each other, and to beat or press the redhot iron introduced between them, so as to flatten it upon two opposite sides. The rotatory cam passing round, the wedge-lever is relieved, when springs instantly throw back the hammers; another cam and wedge-lever now bring the second pair of hammers to act upon the other two sides of the nail in a similar way. This is repeated several times, until the end of the redhot iron rod, gradually advanced by the hands of the workman, has assumed the desired form, that is, has received the bevel and point of the intended nail.

The rod is then withdrawn from between the hammers, and in its heated state is introduced between the jaws of the holders, for cutting off and finishing the nail. A bevel pinion upon the end of the main shaft, takes into and drives a wheel upon a transverse shaft, which carries a cam that works the lever of the holding jaws. The end of the rod being so held in the jaws or vice, a cutter at the side of a wheel upon the transverse shaft separates, as it revolves, the nail from the end of the rod, leaving the nail firmly held by the jaws. By means of a cam, the heading die is now slidden laterally opposite to the end of the nail in the holding jaws, and by another cam, upon the main shaft, the die is forced forward, which compresses the end of the nail, and spreads out the nail into the form of a head. As the main shaft continues to revolve, the cams pass away, and allow the spring to throw the jaws of the vice open, when the nails fall out; but to guard against the chance of a nail sticking in the jaws, a picker is provided, which pushes the nail out as soon as it is finished.

In order to produce round shafts, as for screw blanks, bolts, or rivets, the faces of the hammers, and the dies for heading, must be made with suitable concavities.

NAILS. (*Exhibition.*) *John Reynolds, Crown Nail Works, Newton Row, Birmingham, Manufacturer.*

A case enclosing a card of cut nails, consisting of upwards of 200 distinct varieties of the most useful strengths and sizes, made of iron, zinc, brass, and copper.

In this manufacture sheets of iron of the proper thickness are cut across by a pair of cutting edges, which are set in motion by machinery; the breadth of these strips is equivalent to the length of the nails to be produced from them; the strip, for the convenience of turning, is fastened into a pair of grips attached to a wood shank, resting when in use upon a support immediately behind the workman. The nail machine consists essentially of a pair of cutting chisels or edges, which work perpendicularly, parallel to each other; a gauge, to determine the breadth of a nail; a pair of grips, into which at the time the wedge of iron falls, and where it is firmly held until the small horizontal hammer strikes it and produces the head, when it is dropped into a box beneath. Brads are not headed, but are simply cut out of each other; that is to say, a deficiency in the parallelism of the cutting edge produces the head and prepares for the head of the next brad to be cut therefrom. Glaziers' brads being simple wedge-like pieces of iron, without any head whatever, are produced by the simple operations of the chisels or cutters.

When tacks are blued they are done in quantities by exposing them to heat in an oven or muffle, or upon an iron plate. Japanning is performed by the ordinary process.

NANKIN, is a peculiarly coloured cotton cloth, originally manufactured in the above named antient capital of China, from a native cotton of a brown yellow hue. Nankin cloth has been long imitated in perfection by our own manufacturers; and is now exported in considerable quantities from England to Canton. The following is the process for dyeing calico a nankin colour.

1. Take 300 pounds of cotton yarn in hanks, being the quantity which four workmen can dye in a day. The yarn for the warp may be about No. 27's, and that for the weft 23's or 24's.

2. For *aluming* that quantity, take 10 pounds of saturated alum, free from iron (see **MORDANT**); divide this into two portions; dissolve the first by itself in hot water, so as to form a solution, of spec. grav. 1° Baumé. The second portion is to be reserved for the galling bath.

3. *Galling*, is given with about 80 pounds of oak bark finely ground. This bark may serve for two quantities, if it be applied a little longer the second time.

4. Take 30 pounds of fresh slaked quicklime, and form with it a large bath of lime-water.

5. *Nitro-Muriate of tin*. For the last bath, 10 or 12 pounds of solution of tin are used, which is prepared as follows :

Take 10 pounds of strong nitric acid, and dilute with pure water till its specific gravity be 26° B. Dissolve in it 4633 grains ($10\frac{1}{2}$ oz. avoird.) of sal ammoniac, and 3 oz. of nitre. Into this solvent, contained in a bottle set in cold water, introduce successively, in very small portions, 28 ounces of grain-tin granulated. This solution, when made, must be kept in a well stoppered bottle.

Three coppers are required, one round, about five feet in diameter, and 32 inches deep, for scouring the cotton; two rectangular coppers tinned inside, each 5 feet long, and 20 inches deep. Two boxes or cisterns of white wood are to be provided, the one for the lime-water bath, and the other for the solution of tin, each about 7 feet long, 32 inches wide, and 14 inches deep; they are set upon a platform 28 inches high. In the middle between these two chests, a plank is fixed, mounted with twenty-two pegs for wringing the hanks upon, as they are taken out of the bath.

6. *Aluming*. After the cotton yarn has been scoured with water, in the round copper, by being boiled in successive portions of 100 pounds, it must be winced in one of the square tinned coppers, containing two pounds of alum dissolved in 96 gallons of water, at a temperature of 165° F. It is to be then drained over the copper, exposed for some time upon the grass, rinsed in clear water, and wrung.

7. The *galling*. Having filled four-fifths of the second square copper with water, 40 pounds of ground oak bark are to be introduced, tied up in a bag of open canvass, and boiled for two hours. The bag being withdrawn, the cotton yarn is to be winced through the boiling tan bath for a quarter of an hour. While the yarn is set to drain above the bath, 28 ounces of alum are to be dissolved in it, and the yarn being once more winced through it for a quarter of an hour, is then taken out, drained, wrung, and exposed to the air. It has now acquired a deep but rather dull yellowish colour, and is ready without washing for the next process. Bablah may be substituted for oak bark with advantage.

8. The *liming*. Into the cistern filled with fresh made lime-water, the hanks of cotton yarn suspended upon a series of wooden rods, are to be dipped freely three times in rapid succession; then each hank is to be separately moved by hand through the lime bath, till the desired carmelite shade appear. A weak soda lye may be used instead of lime water.

9. The *brightening*, is given by passing the above hanks, after squeezing, rinsing, and airing them, through a dilute bath of solution of tin. The colour thus produced is said to resemble perfectly the nankin of China.

Another kind of nankin colour is given by oxide of iron, precipitated upon the fibre of the cloth, from a solution of the sulphate, by a solution of soda. See CALICO-PRINTING.

NAPHTHA, or ROCK-OIL (*Huile pétrole*, Fr.; *Steinöl*, Germ.); the Seneca oil of North America, is an ethereous or volatile oil, which is generated within the crust of the earth, and issues in many different localities. The colourless kind, called naphtha, occurs at Baku, near the Caspian Sea, where the vapours which it exhales are kindled, and the flame is applied to domestic and other economical purposes. Wells are also dug in that neighbourhood, in which the naphtha is collected. Similar petroleum wells exist in the territory of the Birmans, at Yananghoun, upon the river Irawaddy, 80 hours' journey north-east of Pegu, where no less than 520 such springs issue from a pale blue clay, soaked with oil, which rests upon roofing slate. Under the slate is coal containing much pyrites. Each spring yields annually 173 casks of 950 pounds each. Petroleum is also found at Amiano in the duchy of Parma, at Saint Zibio in the grand duchy of Modena, at Neufchatel in Switzerland, at Clermont in France, upon some points of the banks of the Iser, at Gabian, a village near Besières, at Tegernsee in Bavaria, at Val di Noto in Sicily, in Zante, Gallicia, Wallachia, Trinidad, Barbadoes, the United States, Rangoon, near Ava, &c. What is found in the market comes mostly from Trinidad. The city of Parma is lighted with naphtha.

The Persian rock-oil is colourless, limpid, very fluid, of a penetrating odour, a hot taste, and a specific gravity of $0\cdot753$; it is said to boil at 160° F. The common petroleum has a reddish-yellow colour, which appears blue by reflected light, is transparent, has a spec. grav. of $0\cdot836$, and contains, according to Unverdorben, several oils of different degrees of volatility, a little oleine and stearine, resin, with a brown indifferent substance held in solution. By repeated rectifications its density may be reduced to $0\cdot758$ at 60° F. Native naphtha, of specific gravity $0\cdot749$, is said by some to boil at 201° F. The condensed vapour consists of $85\cdot05$ carbon, and $14\cdot30$ hydrogen.

The naphtha procured by distilling the coal oil of the gas works, is of specific gravity $0\cdot857$, boils at 316° F., and consists of, carbon $83\cdot04$, hydrogen $12\cdot31$, and oxygen $4\cdot65$, by my experiments.

Rock-oil is very inflammable; its vapour forms with oxygen gas a mixture which vio-

lently detonates, and produces water and carbonic acid gas. It does not unite with water, but it imparts a peculiar smell and taste to it; it combines in all proportions with strong alcohol, with ether and oils, both essential and unctuous; it dissolves sulphur, phosphorus, iodine, camphor, most of the resins, wax, fats, and softens caoutchouc into a glairy varnish. When adulterated with oil of turpentine, it becomes thick and reddish brown, on being agitated in contact with strong sulphuric acid. A very fine black pigment may be prepared from the soot of petroleum lamps.

NAPHTHA AND ITS USES.—In the *Pharm. Journal* for July, 1848, a notice was inserted about the curative virtue of mineral naphtha in Asiatic cholera, as verified by Dr. Andreosky, physician to the commander-in-chief of the Russian army in Circassia. The naphtha there employed has been long known as the produce of springs on the north-west coast of the Caspian Sea, not far from the town of Derbend, near the Gulf of Baku, which was incorrectly printed Beker. It is surprising that in the instructions of the Petersburg police board just published, as to the proper precautions and best remedies against cholera, then beginning its ravages in that capital, no allusion whatever was made to naphtha, or to Dr. Andreosky's testimony in its favour. Are we hence to infer that the preceding recommendation of that substance is apocryphal, or that it has since lost all credit with the Russian faculty, by whom the police bulletin was prepared?

The soil near Derbent, from which the naphtha oozes into wells about thirty inches deep, is a clay marl, which is thoroughly soaked with that fluid. It has a pale yellow colour, like that of Amiano near Parma, in Italy, but has a specific gravity of 0.853, while that of Amiano is only 0.836. Their boiling point is about 305° Fahr. Submitted to distillation, it affords a colourless fluid of spec. grav. 0.728, which boils at about 176° Fahr., but has acquired an empyreumatic odour, very different from that of the native product. Barbadoes tar of the best kind differs from these naphthas only in containing a little more bitumen, but it is equally fragrant. When distilled it yields a similar lighter naphtha, but likewise empyreumatic. The native substances are composed of 6 atoms of carbon and 6 atoms of hydrogen; or in 100 parts, of 86 and 14, by Hess's analysis.

Mineral petroleum seems to be very different in constitution and qualities from the fetid, factitious tar, derived from the igneous decomposition of pit-coal. The latter, according to Mr. Mansfield, is resolvable into six different substances, which he names *alliole*, *benzole*, *toluole*, *camphole*, *mortuole*, and *nitro-benzole*. I do not believe that a series of similar bodies can be extracted from native bitumen or petroleum. Indeed, he himself informed me that the fluid bitumen at one time pumped up abundantly from the Redding coal mines in Derbyshire, of which I furnished him with a specimen, afford no such distinction of products, a result in accordance with my own experience. These differences between the natural and factitious petroleums lead me to conclude that the former are not the result of igneous action, but of that of water upon carbonaceous matter in the mineral strata. In confirmation of which view it may be observed, that not only in the above-named localities, but also at Monte Ciaro near Piacenza, at the Lake of Tegern in Bavaria, near Neufchatel in Switzerland, in the Department of the Ain in France, &c., the bitumen is accompanied with a copious flow of water, on which it floats, and from which it is skimmed.

Petroleum of various shades, from the green of the Barbadoes springs to the pale yellow of Amiano, has been long known to possess certain medicinal properties. The rock-oil of Barbadoes, or as it has been vulgarly but improperly called, Barbadoes-tar, has been found an useful stimulant to torpid bowels, promoting in such a temperament the alvine discharge. Its chief value, however, is as an external remedy in a variety of cutaneous affections. But petroleum, either by itself, or combined with any of its solvent essential oils or spirits, would in general act rather as an irritant and rubefacient upon the skin in such cases, than as a purifying, cleansing, and soothing application. In this dilemma, the idea occurred of incorporating the green rock-oil with fine curd soap. Thus a truly balsamic compound has been obtained. When the soap, used with water in the usual way, has cleared out the cutaneous pores, a film of the petroleum is deposited in them, powerfully remedial in many of the morbid affections of the skin. Such petrolized soap has been found to be quite a specific in the prickly heat of tropical regions, and of equal efficacy in the fiery eruptions incident to many persons in temperate climates. Hitherto, no method had been devised for mollifying efficaciously the alkalinity of soap, which being, as in the best white curd article, a definite saline compound of stearic acid, and soda in its most caustic condition to the extent of six per cent., cannot fail to excoriate delicate skins. By the present happy invention, each particle of that salt is enveloped with a film of balsam, which mitigates its irritant, without interfering with its detergent quality. Hence we may account for the preference given to the petroline soap by all who habitually use it at the toilet-table.—*Pharm. Journ.* vol. viii. No. 2.

NAPHTHALINE, is a peculiar white crystallizable substance, which may be

extracted by distillation from coal tar. It has a pungent aromatic smell and taste, and a specific gravity of 1.048. It is a solid bicarburet of hydrogen, consisting, by my experiments, of 92.9 of carbon, and 7.1 of hydrogen. It has not been applied to any use.

NAPLES YELLOW (*Jasens minéral*, Fr.; *Neapelgelb*, Germ.); is a fine yellow pigment, called *giallotino*, in Italy, where it has been long prepared by a secret process; for few of the recipes which have been published produce a good colour. It is employed not only in oil painting, but also for porcelain and enamel. It has a fresh, brilliant, rich hue, but is apt to be very unequal in different samples.

The following prescription has been confidently recommended. Twelve parts of metallic antimony are to be calcined in a reverberatory furnace, along with eight parts of red lead, and four parts of oxide of zinc. These mixed oxides being well rubbed together are to be fused; and the fused mass is to be triturated and elutriated into a fine powder. Chromate of lead has in a great measure superseded Naples yellow.

NATRON, is the name of the native sesquicarbonate of soda, which occurs in Egypt, in the west of the Delta; also in the neighbourhood of Fessan, in the province of Sukena in Northern Africa, where it exists under the name of *Trona*, crystallized along with sulphate of soda; near Smyrna, in Tartary, Siberia, Hungary, Hindostan, and Mexico. In the last country, there are several natron lakes, a little to the north of Zucatecas, as well as in many other provinces. In Columbia, 48 miles from Merida, native mineral natron is dug up from the bottom of lakes, in large quantities, under the name of *Urao*.

According to Laugier, the Egyptian natron consists of carbonate of soda 22.44, sulphate of soda 18.35, muriate of soda 38.64, water 14.0, insoluble matter 6.0. *Trona* is composed of carbonate of soda 65.75, sulphate of soda 7.65, muriate of soda 2.63, water 24, insoluble matter 1. The sesquicarbonate may be artificially prepared by boiling for a short time a solution of the bicarbonate. See **NITRATE OF SODA**.

NEALING. See **ANNEALING**.

NEB-NEB, is the East Indian name of Bablah.

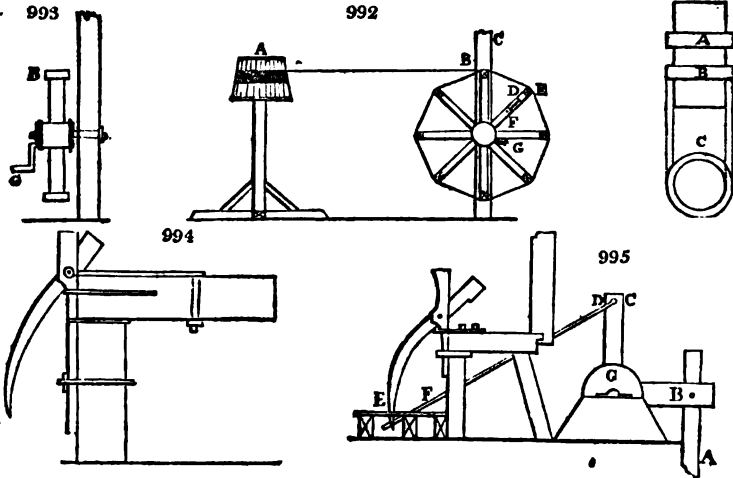
NEEDLE MANUFACTURE. When we consider the simplicity, smallness, and moderate price of a needle, we would be naturally led to suppose that this little instrument requires neither much labour nor complicated manipulations in its construction; but when we learn that every sewing needle, however inconsiderable its size, passes through the hands of 120 different operatives, before it is ready for sale, we cannot fail to be surprised.

The best steel, reduced by a wire-drawing machine to the suitable diameter, is the material of which needles are formed. It is brought in bundles to the needle factory, and carefully examined. For this purpose, the ends of a few wires in each bundle are cut off, ignited, and hardened by plunging them into cold water. They are now snapped between the fingers, in order to judge of their quality; the bundles belonging to the most brittle wires are set aside, to be employed in making a peculiar kind of needles.

After the quality of the steel wire has been properly ascertained, it is calibred by means of a gauge, to see if it be equally thick and round throughout, for which purpose merely some of the coils of the bundle of wires are tried. Those that are too thick are returned to the wire-drawer, or set apart for another size of needles.

The first operation, properly speaking, of the needle factory, is unwinding the bundles of wires. With this view the operative places the coil upon a somewhat conical reel, *fig. 992*, whereon he may fix it at a height proportioned to its diameter. The wire is wound off upon a wheel *n*, formed of eight equal arms, placed at equal distances round a nave, which is supported by a polished round axle of iron, made fast to a strong upright *c*, fixed to the floor of the workshop. Each of the arms is 54 inches long; and one of them *n*, consists of two parts; of an upper part, which bears the cross bar *x*, to which the wire is applied; and of an under part, connected with the nave. The part *x* slides in a slot in the fixed part *r*, and is made fast to it by a peg at a proper height for placing the ends of all the spokes in the circumference of a circle. This arrangement is necessary, to permit the wire to be readily taken off the reel, after being wound tight round its eight branches. The peg is then removed, the branch pushed down, and the coil of wire released. *Fig. 993*, shows the wheel in profile. It is driven by the winch-handle *a*.

The new made coil is cut in two points diametrically opposite, either by hand shears, of which one of the branches is fixed in a block by a bolt and a nut, as shown in *fig. 994*, or by means of the mechanical shears, represented in *fig. 995*. The crank *A* is moved by a hydraulic wheel, or steam power, and rises and falls alternately. The extremity of this crank enters into a mortise cut in the arm *n* of a bent lever *n o c*, and is made fast to it by a bolt. An iron rod *p r*, hinged at one of its extremities to the end of the arm *c*, and at the other to the tail of the shears or chisel *x*, forces it to open and shut alternately. The operative placed upon the floor under *r* presents the coil to the action of the shears, which cut it into two bundles, composed each of 90 or 100 wires, upwards of 8 feet long. The chisel strikes 21 blows in the minute.



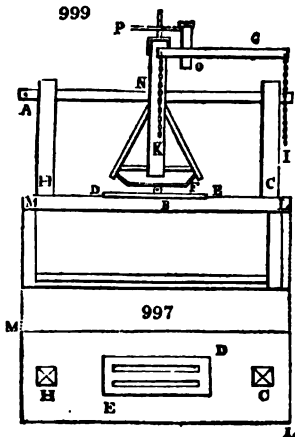
These bundles are afterwards cut with the same shears into the desired needle lengths, these being regulated by the diameter. For this purpose the wires are put into a semi-cylinder of the proper length, with their ends at the bottom of it, and are all cut across by this gauge. The wires, thus cut, are deposited into a box placed alongside of the workman.

Two successive incisions are required to cut 100 wires, the third is lost; hence the shears, striking 21 blows in a minute, cut in 10 hours fully 400,000 ends of steel wire, which produce more than 800,000 needles. The wires thus cut are more or less bent, and require to be straightened. This operation is executed with great promptitude, by means of an appropriate instrument. In two strong iron rings *A*, *fig. 996.*, of which one is shown in front view at *c*, 5000 or 6000 wires, closely packed together, are put; and the bundle is placed upon a flat smooth bench *L*, *fig. 999.*, covered with a cast-iron plate *D*, *x*, in which there are two grooves of sufficient depth for receiving the two ring bundles of wire, or two openings like the rule *r*, *fig. 999.*, upon which is placed the open iron rule *r*, shown in front in *fig. 998.* upon a greater scale. The two rings must be carefully set in the intervals of the rule. By making this rule come and go five or six times with such pressure upon the bundles of wires as causes it to turn upon its axis, all the wires are straightened almost instantaneously.

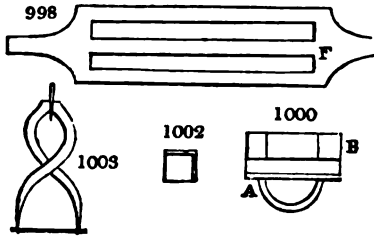
The construction of the machine, represented in *fig. 999.*, may require explanation. It consists of a frame in the form of a table, of which *L* *M* is the top; the cast-iron plate *D* *x* is inserted solidly into it. Above the table, seen in *fig. 997.* in plan, there are two uprights *C* *H*, to support the cross bar *A* *A*, which is held in forks cut out in the top of each of the two uprights. This cross bar *A* *A* enters tightly into a mortise cut in the swing piece *X*, at the point *x*, where it is fixed by a strong pin, so that the horizontal traverse communicated to the cross bar *A* *A* affects at the same time the swing piece *X*. At the bottom of this piece is fixed, as shown in the figure, the open rule *r*, seen upon a greater scale in *fig. 998*.

When the workman wishes to introduce the bundle *B*, he raises, by means of two chains *I*, *X*, *fig. 999.*, and the lever *a* *o*, the swing piece and the cross bar. For this purpose he draws down the chain *I*; and when he has placed the bundle properly, so that the two rings enter into the grooves *x* *D*, *fig. 997.*, he allows the swing piece to fall back, so that the same rings enter the open clefts of the rule *r*; he then seizes one of the projecting arms of the cross bar *A*, alternately pulling and pushing it in the horizontal direction, whereby he effects, as already stated, the straightening of the wires.

The wires are now taken to the pointing-tools, which usually consist of about 30 grindstones arranged in two rows, driven by a water-wheel.



Each stone is about 18 inches in diameter, and 4 inches thick. As they revolve with great velocity and are liable to fly in pieces, they are partially encased by iron plates, having a proper slit in them to admit of the application of the wires.

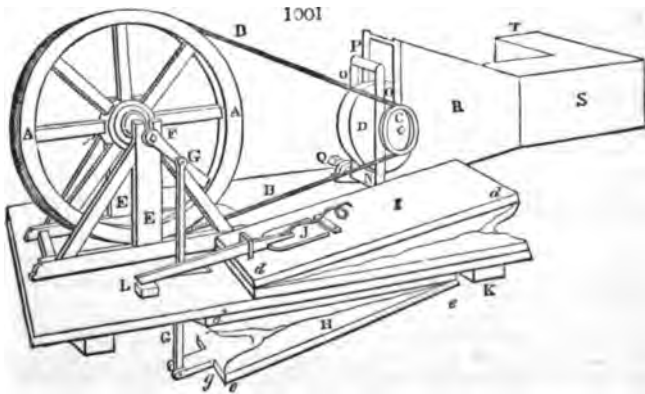


The workman seated in front of the grindstone, seizes 50 or 60 wires between the thumb and forefinger of his right hand, and directs one end of the bundle to the stone. By means of a bit of stout leather called a thumb-piece, of which *A*, *fig. 1000*, represents the profile, and *B* the plan, the workman presses the wires, and turns them about with his forefinger, giving them such a rotatory motion as to make their points conical. This operation, which is called *roughing down*, is dry grinding; because, if water were

made use of, the points of the needles would be rapidly rusted. It has been observed long ago, that the siliceous and steel dust thrown off by the stones, was injurious to the eyes and lungs of the grinders; and many methods have been proposed for preventing its bad effects. The machine invented for this purpose by Mr. Prior, for which the Society of Arts voted a premium, deserves to be generally known.

A, *fig. 1001*, is the fly-wheel of an ordinary lathe, round which the endless cord *n* passes, and embraces the pulley *c*, mounted upon the axle of the grindstone *d*. The fly-wheel is supported by a strong frame *x*, and may be turned by a winch-handle, as usual, or by mechanical power. In the needle factories, the pointing-shops are in general very large, and contain several grindstones running on the same long horizontal shaft, placed near the floor of the apartment, and driven by water or steam power. One of the extremities of the shaft of the wheel *A* has a kneed or bent winch *r*, which by means of an intermediate crank *o*, sets in action a double bellows *u* *v*, with a continuous blast, consisting of the air feeder *h* below, and the air regulator *i* above. The first is composed of two flaps, one of them *a*, being fast and attached to the floor, and the other *e*, moving with a hinge-joint; both being joined by strong leather nailed to their edges. This flap has a tail *g*, of which the end is forked to receive the end of the crank *o*. Both flaps are perforated with openings furnished with valves for the admission of the air, which is thence driven into a horizontal pipe *k*, placed beneath the floor of the workshop, and may be afterwards directed in an uninterrupted blast upon the grindstone, by means of the tin tubes *m* *o*, which embrace it, and have longitudinal slits in them. A brass socket is supposed to be fixed upon the ground; it communicates with the pipe *k*, by means of a small copper tube, into which one of the extremities of the pipe *n* is fitted; the other is supported by the point of a screw *q*, and moves round it as a pivot, so as to allow the two upright branches *o*, to be placed at the same distance from the grindstone. These branches are soldered to the horizontal pipe *n*, and connected at their top by the tube *r*.

The wind which escapes through the slits of these pipes blows upon the grindstone, and carries off its dust into a conduit *s*, *fig. 1001*, which may be extended to *s*, beyond the wall of the building, or bent at right angles, as at *t*, to receive the conduits of the other grindstones of the factory.



A safety valve *z*, placed in an orifice formed in the regulator flap *i*, is kept shut by a

spiral spring of strong iron wire. It opens to allow the superfluous air to escape, when, by the rising of the bellows, the tail *L* presses upon a small piece of wood, and thereby prevents their being injured.

The wires thus pointed at both ends are transferred to the first workshop, and cut in two, to form two needles, so that all of one quality may be of equal length. For each sort a small instrument, *fig. 1002*, is employed, being a copper plate nearly square, having a turned up edge only upon two of its sides: the one of which is intended to receive all the points, and the other to resist the pressure of the shears. In this small tool a certain number of wires are put with their points in contact with the border, and they are cut together flush with the plate by means of the shears, *fig. 994*, which are moved by the knee of the workman. The remainder of the wires are then laid upon the same copper or brass tool, and are cut also even; there being a trifling waste in this operation. The pieces of wire out of which two needles are formed are always left a little too long, as the pointer can never hit exact uniformity in his work.

These pointed wires are laid parallel to each other in little wooden boxes, and transferred to the head-flattener. This workman, seated at a table with a block of steel before him, about 3 inches cube, seizes in his left hand 20 or 25 needles, between his finger and thumb, spreading them out like a fan, with the points under the thumb, and the heads projecting; he lays these heads upon the steel block, and with a small flat-faced hammer strikes successive blows upon all the heads, so as to flatten each in an instant. He then arranges them in a box with the points turned the same way.

The flattened heads have become hardened by the blow of the hammer; when annealed by heating and slow cooling, they are handed to the *piercer*. This is commonly a child, who laying the head upon a block of steel, and applying the point of a small punch to it, pierces the eye with a smart tap of a hammer, applied first upon the one side, and then exactly opposite upon the other.

Another child trims the eyes, which he does by laying the needle upon a lump of lead, and driving a proper punch through its eye; then laying it sidewise upon a flat piece of steel, with the punch sticking in it, he gives it a tap on each side with his hammer, and causes the eye to take the shape of the punch. The operation of piercing and trimming the eyes is performed by clever children with astonishing rapidity; who become so dexterous as to pierce with their punch a human hair, and thread it with another, for the amusement of visitors.

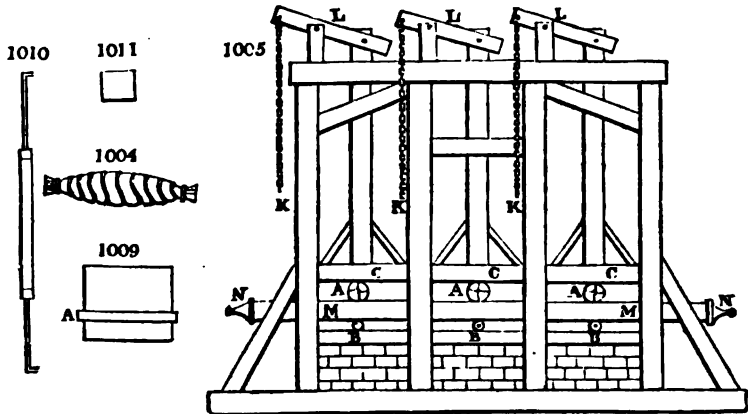
The next operative makes the groove at the eye, and rounds the head. He fixes the needle in pincers, *fig. 1003*, so that the eye corresponds to their flat side; he then rests the head of the needle in an angular groove, cut in a piece of hard wood fixed in a vice, with the eye in an upright position. He now forms the groove with a single stroke of a small file, dexterously applied, first to the one side of the needle, and then to the other. He next rounds and smooths the head with a small flat file. Having finished, he opens the pincers, throws the needle upon the bench, and puts another in its place. A still more expeditious method of making the grooves and finishing the heads has been long used in most English factories. A small ram is so mounted as to be made to rise and fall by a pedal lever, so that the child works the tool with his foot; in the same way as the heads of pins are fixed. A small die of tempered steel bears the form of the one channel or groove, another similar die that of the other, both being in relief; these being worked by the lever pedal, finish the grooving of the eye at a single blow, by striking against each other, with the head of the needle between them.

The whole of the needles thus prepared are thrown pell-mell into a sort of drawer or box, in which they are by a few dextrous jerks of the workman's hand made to arrange themselves parallel to each other.

The needles are now ready for the tempering; for which purpose they are weighed out in quantities of about 30 pounds, which contain from 250,000 to 500,000 needles, and are carried in boxes to the *temperer*. He arranges these upon sheet-iron plates, about 10 inches long, and 5 inches broad, having borders only upon the two longer sides. These plates are heated in a proper furnace to bright redness for the larger needles, and to a less intense degree for the smaller; they are taken out, and inverted smartly over a cistern of water, so that all the needles may be immersed at the same moment, yet distinct from one another. The water being run off from the cistern, the needles are removed, and arranged by agitation in a box, as above described. Instead of heating the needles in a furnace, some manufacturers heat them by means of a bath of melted lead in a state of ignition.

After being suddenly plunged in the cold water, they are very hard and excessively brittle. The following mode of tempering them is practised at Neustadt. The needles are thrown into a sort of frying-pan along with a quantity of grease. The pan being placed on the fire, the fatty matter soon inflames, and is allowed to burn out; the needles are now found to be sufficiently well tempered. They must, however, be re-adjusted upon the steel anvil, because many of them get twisted in the hardening and tempering.

Polishing is the longest, and not the least expensive process in the needle manufacture. This is done upon bundles containing 500,000 needles; and the same machine under the guidance of one man, polishes from 20 to 30 bundles at a time; either by water or steam power. The needles are rolled up in canvas along with some quartzose sand interstratified between their layers, and the mixture is besmeared with rape-seed oil. Fig. 1004 represents one of the rolls or packets of needles 12 inches long, strongly bound with cords. These packets are exposed to the to-and-fro pressure of wooden tables, by which they are rolled about, with the effect of causing every needle in the bundle to rub against its fellow, and against the silicious matter, or emery, enclosed in the bag. Fig. 1005 represents an improved table for polishing the needles by attrition-bags. The lower table *x x* is moveable, whereas in the old constructions it was fixed; the table *c* has merely a vertical motion, of pressure upon the bundles, whereas



formerly it had both a vertical and horizontal motion. Several bundles may obviously be polished at once in the present machine. The table *x x* may be of any length that is required, and from 24 to 27 inches broad; resting upon the wooden rollers *a, a, a*, placed at suitable distances, it receives a horizontal motion, either by hand or other convenient power; the packets of needles *a, a, a*, are laid upon it, and over them the tables *c, c, c*, which are lifted by means of the chains *x, x, x*, and the levers *l, l, l*, in order to allow the needles to be introduced or removed. The see-saw motion forces the *rouleaux* to turn upon their own axes, and thereby creates such attrition among their contents as to polish them. The workman has merely to distribute these rolls upon the table *x*, in a direction perpendicular to that in which the table moves; and whenever one of them gets displaced, he sets it right, lifting by the help of the chain the loaded table. The table makes about 20 horizontal double vibrations in the minute; whereby each bundle, running over 24 inches each time, passes through 40 feet per minute, or 800 yards in the hour.

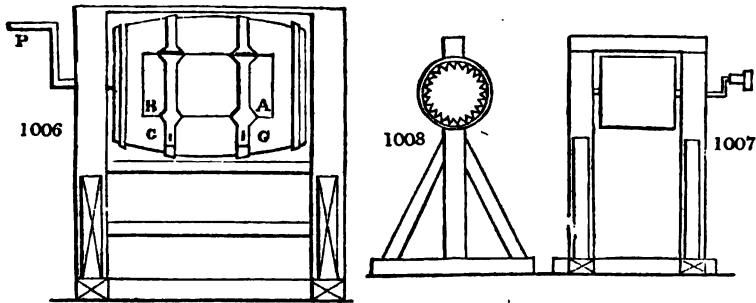
Scouring by the cask. After being worked during 18 or 20 hours under the tables, the needles are taken out of the packets, and put into wooden bowls, where they are mixed with sawdust to absorb the black grease upon their surfaces. They are next introduced into a cask, *fig. 1006*, and a workman seizing the winch *r*, turns it round a little; he now puts in some more sawdust at the door, *a, a*, which is then shut by the clasps *a a*, and continues the rotation till the needles be quite clean and clear in their eyes; which he ascertains by taking out a sample of them from time to time.

Winnowing is the next process, by means of a mechanical ventilator similar to that by which corn is winnowed. The sawdust is blown away, and the grinding powder is separated from the needles, which remain apart clean and bright.

The needles are in the next place arranged in order, by being shaken, as above described, in a small somewhat concave iron tray. After being thus laid parallel to each other, they are shaken up against the end of the tray, and accumulated in a nearly upright position, so that they can be seized in a heap and removed in a body upon a pallet knife, with the help of the forefinger.

The preceding five operations, of making up the *rouleaux*, rolling them under the tables, scouring the needles in the cask, winnowing, and arranging them, are repeated

ten times in succession, in manufacturing the best articles; the only variation being in the first process. Originally the bundles of needles are formed with alternate layers of siliceous schistus and needles; but after the seventh time, bran freed from flour by sifting is substituted for the schistus. The subsequent four processes are, however, repeated as described. It has been found in England, that emery powder mixed with quartz and mica or pounded granite, is preferable to every thing else for polishing needles at first by attrition in the bags; at the second and following operations, emery mixed with olive oil is used, up to the eighth and ninth, for which putty or oxide of tin with oil is substituted for the emery; at the tenth the putty is used with very little oil; and lastly bran is employed to give a finish. In this mode of operating, the needles are scoured in the copper cask shown in elevation in *fig. 1007*., and in section in *fig. 1008*., The inner surface of this cask is studded with points to increase the friction among the needles; and a quantity of hot soap suds is repeatedly introduced to wash them clean. The cask must be slowly turned upon its axis, for fear of injuring the mass of needles which it contains.



They are finally dried in the wooden cask by attrition with sawdust; then wiped individually with a linen rag or soft leather; when the damaged ones are thrown aside.

Sorting of the needles. This operation is performed in a dry upper chamber, kept free from damp by proper stoves. Here all the points are first laid the same way; and the needles are then picked out from each other in the order of their polish. The sorting is effected with surprising facility. The workman places 2000 or 3000 needles in an iron ring, *fig. 1009*., two inches in diameter, and sets all their heads in one plane; then on looking carefully at their points, he easily recognises the broken ones; and by means of a small hook fixed in a wooden handle, *fig. 1010*., he lays old of the broken needle, and turns it out. These defective needles pass into the hands of another workman, who points them anew upon a grindstone, and they form articles of inferior value. The needles which have got bent in the polishing must now be straightened. The whole are finally arranged exactly according to their lengths by the tact of the finger and thumb of the sorter.

The needles are divided into quantities for packing in blue papers, by putting into a small balance the equivalent weight of 100 needles, and so measuring them out without the trouble of counting them individually.

The *Wuer* receives these packets, and taking 25 of their needles at a time between the forefinger and thumb, he presses their points against a very small hone-stone of compact micaceous schist, mounted in a little lathe, as shown in *fig. 1011*., he turns them briskly round, giving the points a bluish cast, while he polishes and improves them. This partial polish is in the direction of the axis; that of the rest of the needles is transverse, which distinguishes the boundaries of the two. The little hone-stone is not cylindrical, but quadrangular, so that it strikes successive blows with its corners upon the needles as it revolves, producing the effect of filing lengthwise. Whenever these angles seem to be blunted, they are set again by the *Wuer*.

It is easy to distinguish good English needles from spurious imitations; because the former have their axis coincident with their points, which is readily observed by turning them round between the finger and thumb.

The construction of a needle requires, as already stated, about 120 operations; but they are rapidly and uninterruptedly successive. A child can *trim* the eyes of 4000 needles per hour.

When we survey a manufacture of this kind, we cannot fail to observe, that the diversity of operations which the needles undergo bears the impress of great mechanical refinement. In the arts, to divide labour, is to abridge it; to multiply operations, is to simplify them; and to attach an operative exclusively to one process, is to render him much more economical and productive.

NEROLI, is the name given by perfumers to the essential oil of orange flowers. It is procured by distillation with water, in the same way as most other volatile oils. Since in distilling water from neroli, an aroma is obtained different from that of the orange-flower, it has been concluded that the distilled water of orange-flowers owes its scent to some principle different from an essential oil.

NET (*Filet, resaw, Fr.*; *Netz, Germ.*); is a textile fabric of knotted meshes, for catching fish, and other purposes. Each mesh should be so secured as to be incapable of enlargement or diminution. The French government offered in 1802 a prize of 10,000 francs to the person who should invent a machine for making nets upon automatic principles, and adjudged it to M. Buron, who presented his mechanical invention to the *Conservatoire des Arts et Métiers*. It does not appear, however, that this machine has accomplished the object in view; for no establishment was ever mounted to carry it into execution. Nets are usually made by the fishermen and their families during periods of leisure. The formation of a mesh is too simple a matter to require description in this Dictionary.

NEUTRALIZATION, is the state produced when acid and alkaline matters are combined in such proportions that neither predominates, as evinced by the colour of tincture of litmus and cabbage remaining unaffected by the combination.

NICARAGUA WOOD, is the wood of the *Casalpinia echinata*, a tree which grows in Nicaragua. It is used with solution of tin as a mordant to dye a bright but fugitive red. It is an inferior sort of Brazil wood.

NICKEL, is a metal rather sparingly found, and in few localities; being usually associated with cobalt. Native nickel occurs at Westerwald in the Erzgebirge, in Bohemia, combined with arsenic, under the significant name of *Kupfernichel*; with cobalt, iron, and copper, as *Arsenic-nickel*, in the Harz; at Riechelsdorf in Hessian; as an oxide, in *Nichelschwürze*; as a sulphuret of nickel in *Haarkies*; as a sulphuret and arseniate of nickel in *Nichselglanz*; and with sulphur and antimony in *Nichelspiess glanzertz* at Siegen. Nickel is always present in meteoric stones. Kupfernichel occurs in numerous external shapes; as reniform, globular, botroidal, arborescent, massive, and disseminated; fracture, coarse or fine grained, with metallic lustre; colour, copper red, occasionally brown and gray; in silver and cobalt veins, in gneiss, mica-slate, kupfer-schiefer, accompanied by speisse cobalt, native silver, quartz, &c. It is found in Westphalia near Olpe, in Hessian at Riechelsdorf, and Biber, in Baden; in the Saxon Erzgebirge near Schneeberg, and Freiberg; in Bohemia, at Joachimsthal; in Thuringia, at Saalfeld; in Steyermark near Schladming; in Hungary, France, and England.

Since the manufacture of German silver, or *Argentane*, became an object of commercial importance, the extraction of nickel has been undertaken upon a considerable scale. The cobalt ores are its most fruitful sources, and they are now treated by the method of Wöhler, to effect the separation of the two metals. The arsenic is expelled by roasting the powdered *speiss* first by itself, next with the addition of charcoal powder, till the garlic smell be no longer perceived. The residuum is to be mixed with three parts of sulphur and one of potash, melted in a crucible with a gentle heat, and the product being edulcorated with water, leaves a powder of metallic lustre, which is a sulphuret of nickel free from arsenic; while the arsenic associated with the sulphur, and combined with the resulting sulphuret of potassium, remains dissolved. Should any arsenic still be found in the sulphuret, as may happen if the first roasting heat was too great, the above process must be repeated. The sulphuret must be finally washed, dissolved in concentrated sulphuric acid, with the addition of a little nitric; the metal is to be precipitated by a carbonated alkali, and the carbonate reduced with charcoal.

In operating upon kupfernichel, or *speiss*, in which nickel predominates, after the arsenic, iron, and copper have been separated, ammonia is to be digested upon the mixed oxides of cobalt and nickel, which will dissolve them into a blue liquor. This being diluted with distilled water deprived of its air by boiling, is to be decomposed by caustic potash, till the blue colour disappears, when the whole is to be put into a bottle tightly stoppered, and set aside to settle. The green precipitate of oxide of nickel, which slowly forms, being freed by decantation from the supernatant red solution of oxide of cobalt, is to be edulcorated and reduced to the metallic state in a crucible containing crown glass. Pure nickel in the form of a metallic powder is readily obtained by exposing its oxalate to moderate ignition.

The reduction of the oxide of nickel with charcoal requires the heat of a powerful air furnace or smith's forge.

Nickel possesses a fine silver white colour and lustre; it is hard, but malleable, both hot and cold; may be drawn into wire $\frac{1}{16}$ of an inch, and rolled into plates $\frac{1}{32}$ of an inch thick. A small quantity of arsenic destroys its ductility. When fused it has a specific gravity of 8.279 and when hammered of 8.66 or 8.82; it is susceptible of magnetism, in a somewhat inferior degree to iron, but superior to cobalt. Mariner's compasses may be made of it. Its melting point is nearly as high as that of manganese. It is not oxidized by contact of air, but may be burned in oxygen gas.

There is one oxide and two suroxides of nickel. The oxide is of an ash-gray colour, and is obtained by precipitation with an alkali from the solution of the muriate or nitrate. The niccolous suroxide of Berzelius is black, and may be procured by exposing the nitrate to a heat under redness. The niccolie suroxide has a dirty pale green colour; but its identity is doubtful.

Nickel may be detected by cyanide of potassium in an acid solution of it and cobalt; the cyanide being added until the precipitate first formed is redissolved: dilute sulphuric acid is then added, and the mixture warmed and allowed to stand. A precipitate appearing shows the presence of nickel, whether it be cobalt cyanide or simple cyanide of nickel.

Nickel, (analysis of), by H. Rose. Nickel and cobalt are almost always associated together, and are very difficult to separate.

Upon the fact that in a solution of oxide of cobalt containing free muriatic acid the whole of the metal is converted into the super-oxide, by means of chlorine, while the chloride of nickel remains unaltered in the acid solution, Mr. H. Rose based a successful method for the separation of the metals. His method is as follows:— Both metals are dissolved in hydrochloric acid; the solution must contain a sufficient excess of free acid; it is then diluted with much water; if 1 or 2 grammes of the oxide are operated on, about 2 lbs. of water are added to the solution. As cobalt possesses a much greater colouring power than nickel, not only in fluxes but also in solutions, the diluted solution is of a rose colour, even when the quantity of nickel present greatly exceeds that of the cobalt. A current of chlorine gas is then passed through the solution for several hours; the fluid must be thoroughly saturated with it, and the upper part of the flask above the liquid must remain filled with the gas after the current has ceased. Carbonate of baryta in excess is then added, and the whole allowed to stand for 12 or 18 hours, and frequently agitated. The precipitated superoxide of cobalt and the excess of carbonate of baryta are well washed with cold water, and dissolved in hot hydrochloric acid; after the separation of the baryta by sulphuric acid, the cobalt is precipitated by hydrate of potash, and after being washed and dried is reduced in a platinum or porcelain crucible by hydrogen gas. The fluid filtered from the superoxide of cobalt is of a pure green colour. It is free from any trace of cobalt. After the removal of the baryta by means of sulphuric acid, the oxide of nickel is precipitated by caustic potash. Even this method did not give exact results on the first trial. 0·318 gr. metallic nickel and 0·603 gr. metallic cobalt were employed, and 0·430 gr. oxide of nickel and 0·580 gr. cobalt were obtained:—

| | Employed | Obtained |
|----------------|----------|----------|
| Nickel - - - - | 34·53 | 36·75 |
| Cobalt - - - - | 65·47 | 62·98 |
| | <hr/> | <hr/> |
| | 100·00 | 99·73. |

The cause of these incorrect results is, that the solution was filtered an hour or two after the precipitation of the superoxide of cobalt by the carbonate of baryta. It is necessary, however, to wait a considerable time, at least twelve hours, or even eighteen is better, and allow the excess of carbonate of baryta to remain in contact with the solution, as the superoxide of cobalt is precipitated very slowly: this explains the diminution of the cobalt and increase of the nickel in the above experiment.

In another experiment, in which this source of error was avoided, 0·799 gr. metallic nickel and 0·540 metallic cobalt were used, and 0·548 gr. cobalt obtained, that is, 42·84 per cent. instead of 42·22; the nickel was not determined. Two experiments were made by M. Weber. In one, 0·818 gr. cobalt, and 0·980 gr. nickel, were taken, and 0·806 gr. cobalt and 1·274 oxide nickel obtained.

| | Used | Obtained |
|----------------|--------|----------|
| Cobalt - - - - | 45·50 | 44·77 |
| Nickel - - - - | 54·50 | 55·83 |
| | <hr/> | <hr/> |
| | 100·00 | 100·60 |

In the second 0·516 gr. metallic cobalt and 0·637 oxide of nickel were taken, and 0·517 gr. cobalt obtained.

It will be seen from these experiments, that on the proper precautions being taken, very accurate results may be obtained by this method. It has also this advantage, that it is equally applicable whatever the relative proportions of the cobalt may be.

This or a similar method may be employed with advantage on a large scale, to procure cobalt and nickel in the purest state. Both metals are more employed in the arts than formerly; and in many cases it is important to prepare them as pure as possible. This

is the case when oxide of cobalt is to be employed in printing on porcelain, when a very small portion of nickel seriously affects the purity of the blue tint to be obtained by it. I have at least prepared the pure oxides of nickel and cobalt used in my laboratory in this manner; and in the experiments described above, none but the oxides so prepared were used. The nickel which occurs in commerce contains besides traces of arsenic, cobalt, copper and iron. It should be dissolved in hydrochloric acid, and the cobalt and iron separated by treatment with chlorine and carbonate of baryta, and then the copper precipitated by sulphuretted hydrogen.

It will be readily perceived, that not only cobalt, but also other metals, as iron and manganese, may be separated from nickel by this method. On the other hand, oxide of cobalt may be separated from the oxide of zinc, and other strongly basic oxides, which are not converted into superoxides. Nickel and cobalt can moreover be separated from metals to which they bear a close analogy in various ways. I have given a method in my "Manual of Analytical Chemistry," by which both these metals may be separated from manganese, viz., by converting them into chlorides, and treating these by hydrogen, which reduces the chlorides of nickel and cobalt to the metallic state, but not the chloride of manganese. This method affords accurate results, but is rather complicated. Völker has remarked, that at a very strong heat the chloride of manganese is slightly volatile. Although this is inappreciable except when the heat has been raised too high, still it is possible to effect their separation by simpler methods.

With many other chemists, I have convinced myself, that the method of Barresvil for the separation of the oxides of cobalt and manganese, by adding carbonate of baryta to the solution, and passing a current of sulphuretted hydrogen through it, is not applicable, since, as indeed might be seen *a priori*, not only the oxide of cobalt, but also the oxide of manganese, will be precipitated as a sulphuret.

From nickel, the manganese may be best separated in the same manner as cobalt, as I have remarked above. Manganese may be separated from both of them, however, by a method which, in its essential parts, was proposed by Wackenroder. It is based upon the fact, that although nickel and cobalt are not precipitated from their solutions by sulphuretted hydrogen, especially when they are slightly acid, still the sulphurets precipitated by hydrosulphate of ammonia are not dissolved by very dilute hydrochloric acid. I long ago, in the first edition of my "Manual of Analytical Chemistry," directed attention to this curious property, and made use of it for qualitative experiments, but at that time had not availed myself of it in quantitative separations. When the oxides are contained in an acid solution, (which should not contain nitric acid however), it is made ammoniacal, and they are precipitated as sulphurets by hydrosulphate of ammonia. Very dilute hydrochloric acid is then added to the solution, until it has a very slightly acid reaction; the sulphurets of nickel and cobalt remain undissolved; they are washed with water containing a little sulphuretted hydrogen and a trace of hydrochloric acid. The sulphuret of manganese is dissolved with facility, but although the fluid filtered from the sulphurets of nickel and cobalt gives only a rather dirty flesh-coloured precipitate on the addition of ammonia and hydrosulphate of ammonia, still the sulphuret of manganese contains small portions of sulphuret of cobalt or nickel; and when therefore it is treated anew with very dilute hydrochloric acid, minute quantities of the black sulphurets remain behind. By this repeated treatment, a very nearly correct separation may be obtained; but the results are more satisfactory in the separation of cobalt from manganese than of nickel from the latter metal, evidently because nickel is not very perfectly precipitated by hydrosulphate of ammonia: 0.300 gr. of metallic cobalt and 0.385 gr. of deutoxide of manganese gave—after the sulphuret had been converted by *aqua regia* into oxide, and this precipitated by hydrate of potash, and after the chloride of manganese dissolved was free from sulphuretted hydrogen and precipitated by carbonate of soda,—0.302 metallic cobalt and 0.392 oxide of manganese.

0.251 gr. of oxide of nickel, and 0.296 gr. oxide of manganese, treated in the same manner gave 0.214 oxide of nickel and 324 oxide of manganese.

Iron also may be separated from nickel, and better still from cobalt, in the same manner as manganese, since sulphuret of iron, like sulphuret of manganese, is easily soluble in very dilute hydrochloric acid; but in this case the resolution of the sulphuret of iron is likewise necessary: 0.425 gr. metallic cobalt and 0.170 gr. sesquioxide of iron, when treated in this manner, gave 0.414 gr. metallic cobalt, and 0.172 sesquioxide of iron.

I have already stated, in the last edition of my "Manual of Analytical Chemistry," that the oxide of zinc may be completely precipitated from its solution in acetic acid by means of sulphuretted hydrogen when no strong inorganic acid is present, even though the solution contain a large excess of acetic acid; and recommended the separation of this oxide from alumina, the oxides of iron, manganese, and even from those of cobalt and nickel, by this method. This method also succeeds when a considerable addition of acetic acid is made to the solution, especially if the latter oxides are present.

From alumina oxide of nickel may be separated by fusing them together with hydrate of potash in a silver crucible; on treating the fused mass with water, the oxide of nickel remains behind in a dense state. It weighs rather more than the oxide employed, but contains no alumina, and potash must therefore be present. 0.238 gr. oxide of nickel mixed with alumina weighed, after it had been treated in this manner, 0.245 gr. By boiling with a solution of potash, nickel cannot be separated from alumina, when both are contained in a solution, not even when the treatment is repeated. When the 0.245 gr. was dissolved in hydrochloric acid with the help of a little sulphuric acid, and the separated solution of alumina in potash, to which more potash was added, mixed with the solution, and the whole boiled, the oxide of nickel separated weighed 0.320 gr. When this was dissolved in hydrochloric acid, a considerable quantity of alumina separated on the addition of ammonia in excess. As, however, the fusion of hydrate of potash in a silver crucible is attended with inconvenience, and the oxide of nickel obtained requires to be dissolved and precipitated anew, the separation of these oxides by means of carbonate of baryta is preferable.

I have tried in vain, by fusing with a fixed alkaline carbonate, to separate quantitatively alumina from the oxides of cobalt and nickel, and from those of other metals which are incapable of expelling the carbonic acid from an alkaline carbonate at an elevated temperature. It is difficult to obtain a perfectly clear solution by fusing alumina with carbonated alkali, and treating the melted mass with water; it is quickly rendered turbid by the carbonic acid of the atmosphere. A fused mass is much more easily obtained with carbonate of soda than with carbonate of potash.

Nickel and Cobalt.—Mingled with the beautiful samples of copper pyrites and argentiferous galena displayed in Class 1. of the Great Exhibition, there were to be found several specimens of cobalt and nickel ores. These valuable articles lay buried beneath the huge bulk of their better known compeers, and, unless sought for, would fail to arrest the attention even of a scientific observer; thus singularly illustrating in the Crystal Palace the obscure position they occupy in the manufacturing industry of the nation. The art of working the ores of cobalt and nickel seems unknown in Great Britain, if we may judge by the fact that, though found in sufficient abundance, they are nowhere in this country converted into zaffre and speiss, the two primary marketable products elsewhere obtained from these ores. Although, therefore, no nation in the world consumes in its manufactures more cobalt and nickel than Great Britain, yet for these metals it is entirely dependent upon Norway, Northern Germany and the Netherlands; from whence we import annually not less than 400 tons of zaffre and smalts, and nearly the same quantity of nickel and speiss, to the conjoint value of about 150,000*l.* sterling. As these substances serve very different purposes in the arts, we propose to speak of them separately,—merely premising that cobalt forms the bases of all the blue colours seen on earthenware, whilst nickel is an indispensable ingredient in the various metallic alloys, known under the terms albatra, German silver, &c. The specimens of ore previously alluded to as existing in the Great Exhibition have been derived from Cornwall, and contain, as is generally the case, both nickel and cobalt, thus far being precisely similar to the ores worked in Norway and Northern Germany. The foreign ores are, however, much richer than the Cornish, since these latter seldom contain more than from 2 to 7 per cent. of available metallic matter, whilst the former not unfrequently yield 12 or 15 per cent.; consequently, a process which answers quite well with the one may fail altogether, or prove profitless with the other; and this is exactly the whole secret of our national failure in working cobalt ore. The Swedish method has been tried in several parts of Cornwall, and has not in any one instance given a satisfactory result; hence, the Crystal Palace contains no specimen of British zaffre, and our potteries, glass works, and paper manufacturers procure from abroad that which ignorance and apathy deny them at home. In the German ore the quantity of metallic ingredients is not only larger than in the Cornish, but also of a more fusible character; consequently, when simply subjected to heat in a reverberatory furnace, the earthy and metallic elements separate of themselves by the mere disparity of their specific weights; and the siliceous gangue, with a portion of oxide of iron, rises to the top; leaving a metallic compound of arsenic, cobalt, nickel, copper, and perhaps iron beneath. This latter, when carefully roasted in an oxidizing furnace, in contact with sand or ground flint, affords at once an impure silicate of cobalt and arseniuret of nickel,—two marketable products. The Cornish ores, from their metallic poverty, will not undergo the first fusion necessary to separate the siliceous matrix of the mineral; and this trifling impediment seems actually to have denuded the energy of that indomitable spirit of enterprise for which Britain is in most things justly celebrated. In the manufacture of iron, limestone is used to render the alumina and silica of the ore fusible; and without this no iron can be procured by the ordinary process. In roasting lead ore, lime cannot be dispensed with. In copper making, not only lime but also fluor spar is frequently needed; and the commonest cobalt ores of Cornwall clearly require nothing but a proper flux to afford

a compound of arsenic, cobalt, and nickel, perfectly analogous to that procured from the German ore by mere fusion without a flux. The whole question, therefore, really resolves itself into the discovery of a cheap material capable of easy vitrification with the granitic matrix of the Cornwall ore, and which is nevertheless devoid of action upon the arseniuret of cobalt and nickel. The common fixed alkalis, though answering the first indication admirably, would not comply with the second condition; hence potash and soda, these great helpmates of industrial skill, are unfortunately excluded from the list of agents, as they act powerfully upon all the arseniurets, and would merely produce a worthless frit with the ore. Similar objections attach more or less to the alkaline earths, and therefore lime requires to be looked upon with suspicion. Borax would and does yield a satisfactory result, but its high price is an insurmountable obstacle. Fluor spar is of no avail, and bottle glass requires too strong a temperature, and to be used in too great a quantity, for economical application to a mineral already surcharged with extraneous matters.

These facts serve in some measure to explain, though we cannot in any way allow that they justify, the present condition of the zaffre market; since these very difficulties are daily overcome in one of the largest metallurgical operations carried on amongst us. Many of the ores of copper, when first received by the manufacturer, are in a state quite parallel to that of the Cornish ores of cobalt, even in regard to poverty of metal. There is the same excess of granitic matrix, the same necessity for avoiding the use of any agent capable of attacking sulphuret of copper, a substance possessing very similar chemical affinities to those of the arseniurets of nickel and cobalt. What then is the flux employed by the copper manufacturer in such cases? We reply at once,—it is the protoxide of iron which is formed from these poor copper ores by the action of heat, and combines with the silicate of the matrix so as to produce an extremely fusible silicate of iron, which permits the sulphuret of copper to fall down to the lower part of the reverberatory furnace, whilst the vitrified impurities of the ore are raked from its surface. Oxide of iron would most probably therefore enable a manufacturer, accustomed to furnace operations, to send into the market an arsenical compound of cobalt containing more than 50 per cent. of this metal, even if his interest failed to convince him of the great advantage resulting from its subsequent conversion into zaffre. Thus, then, the conditions of this seemingly difficult problem are answered, in a commercial sense; for oxide of iron is plentiful and cheap, its combination with silica is sufficiently fusible, and it has no action whatever upon metallic arseniurets. No doubt many other substances might be found equally applicable with the one we have mentioned; and, indeed, our object in thus dilating upon this and analogous topics is rather to stimulate inquiry than to lay down specific rules for practical guidance; consequently our remarks must be regarded at best as but a shadowy outline, the manufacturing details of which require careful filling in, to render the whole intelligible and useful.

Before quitting the subject of cobalt, it may be as well to advert to a particular ore of that metal, found near Keswick in Cumberland. This ore contains from two or three per cent. of cobalt, but is quite free from nickel,—a very unusual circumstance,—as even in meteoric stones cobalt is constantly accompanied by nickel, though this last metal not unfrequently exists without cobalt. As a colouring material, oxide of cobalt is seriously damaged by the presence of oxide of nickel, for these oxides produce colours almost complementary to each other; and therefore tending, by their admixture, to yield a neutral tint, as is observable when their saline solutions are united. The great advantage of working an ore of cobalt free from nickel must consequently be obvious to all. The Keswick mine is, nevertheless, almost abandoned at the present moment, through sheer inability to find a market for its produce; though for the finer kinds of porcelain and for enamel painting, the oxide of cobalt procured from it is worth fully a guinea per pound.

In the hope of drawing attention to a raw material at once so unique and valuable, we give the following original process for extracting pure oxide of cobalt from the Keswick cobalt ore:—Having carefully roasted a quantity of this ore, at a full red heat, in a muffle furnace, for two or three hours, it is next to be reduced to a fine powder, and then digested in muriatic acid of the specific gravity 1.10 or thereabout. And for this use the waste acid of the soda maker is well adapted, even though it may happen to contain arsenic and iron. After a few hours' digestion, the acidulous solution may be poured off and a fresh acid added, so as completely to exhaust the roasted ore, and dissolve all the metallic matter in it. Then mix the solution thus procured; and, having thrown in a portion of powdered hæmatite or other form of peroxide of iron, evaporate the whole to dryness. Next pour boiling water on the dried mass, and stir in an excess of chalk, or finely powdered marble, and preserve the whole at a temperature of about 180° Fahr., until all evolution of carbonic acid ceases; then add a quantity of sulphate of soda, and throw the mixture on a filter, when a solution of chlo-

ride of cobalt will pass through, containing a small quantity of the sulphates of lime and soda, but altogether free from metallic contamination. This solution must now be super-saturated with a caustic lye of soda, and the mixture boiled for a few minutes in order to insure the rapid precipitation of the oxide of cobalt; which, after careful washing with hot water, is to be dried, and heated red hot, in a crucible, to give it the character suitable for the English market. One pound of Keswick ore will require about 8 ounces of muriatic acid, of the kind alluded to, with 2 ounces of hæmatite, 3 ounces of chalk, and the same quantity of salt cake or dry sulphate of soda. The explanation of this process is very simple: in the first instance, the metallic matters of the ore, consisting of iron, cobalt, arsenic, copper, and perhaps also lead, are dissolved by the muriatic acid; and, as all of these are precipitated by carbonate of lime, except cobalt, the chalk might now be added at once, but for the fact that the Keswick ore contains an excess of arsenic, which carries down a portion of cobalt in the state of arsenite of cobalt. To remedy this evil, peroxide of iron or hæmatite must be added, so as to ensure the existence of an excess of peroxide of iron in the solution; as this, on the introduction of the chalk, will unite to the arsenic, and thus prevent the precipitation of any cobalt at this stage of the operation. The cessation of all effervescence, indicates that the chalk has ceased to act, and that the iron, arsenic, copper, and lead are no longer in solution, but have been displaced by the lime of the chalk. To remove this lime, sulphate of soda is employed, since this throws down nearly the whole of the lime in the state of sulphate; after which caustic soda or potash will precipitate nothing from the filtered solution but pure oxide of cobalt. Although apparently somewhat complex in detail, this process is extremely simple and efficient in practice; and possesses, moreover, the advantage of being equally applicable to the treatment of speiss or arseniuret of nickel, from which pure oxide of nickel may be easily procured,—using, however, much more hæmatite than the quantity above indicated, in consequence of the absence of iron in speiss. From this latter circumstance, it must be obvious, that cobalt and nickel cannot be separated in the way just described; for, as has been stated, they both remain in solution after the employment of the chalk; and, indeed, no process has yet been published by which a perfect separation of these two metals can be effected. Ordinary Swedish zaffre contains, on an average, 15 per cent. of oxide of cobalt, mixed with about 3 per cent. of oxide of nickel; which latter seriously impairs the colouring power of zaffre. Hence it is that we have entered thus fully into this question; for as it is almost impossible to purify cobalt when contaminated with nickel, it is a kind of national disgrace to Great Britain that, having a pure ore of cobalt in the very centre of the island, our manufacturers are unable either to compete with, or so much as contest for, the palm of superiority in the formation of zaffre.

NICOTIANINE, is the name of an oil recently extracted from the leaves of tobacco, which possesses the smell of tobacco smoke.

NICOTINE, is a peculiar principle, obtainable from the leaves and seeds of tobacco (*nicotiana tabacum*), by infusing them in acidulous water, evaporating the infusion to a certain point, adding lime to it, distilling, and treating the product which comes over with ether. It is colourless, has an acrimonious taste, a pungent smell, remains liquid at 20° Fahr., mixes in all proportions with water, but is in a great measure separable from it by ether, which dissolves it abundantly. It combines with acids, and forms salts acid and pungent like itself; the phosphate, oxalate, and tartrate being crystallizable. Nicotine causes the pupils to contract. A single drop of it is sufficient to kill a dog.

Macerate powdered tobacco for twenty-four hours in water acidulated with sulphuric acid; express the liquor, evaporate to the consistence of syrup, and distil the residue with a sufficient quantity of potash; add more water from time to time to prevent the decomposition of the nicotina, in consequence of the potash being too much concentrated. From this distillation a quantity of nicotina and ammonia will be obtained in the receiver, and these are to be neutralized with oxalic acid. Evaporate now to dryness, and treat the residue with boiling alcohol, which will dissolve the oxalate of nicotina, leaving the oxalate of ammonia unacted upon. Heat the oxalate of nicotina in solution of potash, and separate the nicotina with ether, in which it is soluble, and from which the ether may again be separated by distillation.

M. Ortigosa considers this nicotina not to be perfectly pure, but to contain a portion of water and of alcohol.

From the analysis of the salt formed by the combination of nicotina with the chlorides of platinum and mercury, M. Ortigosa has represented the composition of this vegetable principle by the following formula:—

$$\begin{aligned} \text{C}_{10} &= 73.26 \\ \text{H}_8 &= 9.65 \\ \text{Az}_1 &= 17.09 \end{aligned}$$

NITRATE OF AMMONIA, is prepared by neutralizing nitric acid with car-

bonate of ammonia, and crystallizing the solution. Heat converts it into water and laughing gas.

NITRATE OF LEAD (*Nitrate de plomb*, Fr.; *Salpetersaures bleioxyd*, Germ.); is made by saturating somewhat dilute nitric acid with oxide of lead (litharge), evaporating the neutral solution till a pellicle appears, and then exposing it in a hot chamber till it be converted into crystals, which are sometimes transparent, but generally opaque white octahedrons. Their spec. grav. is 4.068; they have a cooling, sweetish, pungent taste. They dissolve in 7 parts of cold, and in much less boiling water; they fuse at a moderate elevation of temperature, emit oxygen gas, and pass into oxide of lead. Their constituents are 67.3 oxide and 32.7 acid. Nitrate of lead is much employed in the chrome yellow style of **CALICO-PRINTING**; which see.

There are three other compounds of nitric acid and lead oxide; viz. the bi-basic, the tri-basic, and the se-basic; which contain respectively 2, 3, and 6 atoms of base to 1 of acid.

NITRATE OF POTASH, *Nitre, salpêtre*. (*Nitrate de potasse*, Fr.; *Salpetersaures kali*, Germ.) This salt occurs native as an efflorescence upon limestones, sandstones, marls, chalk, and calcuff; it forms a saline crust in caverns, as also upon the surface of the ground in certain places, especially where animal matters have been decomposed. Such caverns exist in Germany near Homburg (Burkardush); in Apulia upon the Adriatic sea (Pulo di Mofetta); in France; in the East Indies; in Ceylon, where 22 nitriferous caverns are mentioned; in North America, at Crooked river, Tennessee, Kentucky, and upon the Missouri; in Brazil, Teneriffe, and Africa. Nitre occurs as an efflorescence upon the ground in Arragon, Hungary, Podolia, Sicily, Egypt, Persia, Bengal, China, Arabia, North America, and South America. Several plants contain saltpetre; particularly borage, dill, tobacco, sunflowers, stalks of maize, beet-root, bugloss, parietaria, &c. It has not hitherto been found in animal substances.

The question has been frequently put; how is nitre annually reproduced upon the surface of limestones and the ground, after it has been removed by washing? It has been said, in reply, that as secondary limestones contain remains of animal matters, the oxygen of the atmosphere, absorbed in virtue of the porous structure, will combine with their azote to form nitric acid; whence nitrate of lime will result. Where potash is present in the ground, a nitrate of that base will be next formed. The generation of nitre is in all cases limited to a very small distance from the surface of porous stones; no further, indeed, than where atmospherical air and moisture can penetrate; and none is ever produced upon the surface of compact stones, such as marble and quartz, or of argillaceous minerals. Dr. John Davy and M. Longchamp have advanced an opinion, that the presence of azotized matter is not necessary for the generation of nitric acid or nitrous salts, but that the oxygen and azote of the atmosphere, when condensed by capillarity, will combine in such proportions as to form nitric acid, through the agency of moisture and of neutralizing bases, such as lime, magnesia, potash, or soda. They conceive that as spongy platina serves to combine oxygen and hydrogen into water, or the vapour of alcohol and oxygen into acetic acid, and as the peroxide as well as the hydrate of iron, and argillaceous minerals, serve to generate ammonia from the oxygen of the air and the hydrogen of water; in like manner, porous limestones, through the agency of water, operate upon the constituents of the atmosphere to produce nitric acid, without the presence of animal matter. This opinion may certainly be maintained; for in India, Spain, and several other countries, at a distance from all habitations, immense quantities of saltpetre are reproduced in soils which have been washed the year before. But, on the other hand, it is known that the production of this salt may be greatly facilitated and increased by the admixture of animal offals with calcareous earths.

The spontaneous generation of nitre in Spain, Egypt, and especially in India, is insufficient to supply the wants of the whole world. There this salt is observed to form upon the surface of the ground in silky tufts, or even in slender prismatic crystals, particularly during the continuance of the hot weather that succeeds copious rains. These saline efflorescences, after being collected by rude besoms of broom, are lixiviated, allowed to settle, evaporated, and crystallized. In France, Germany, Sweden, Hungary, &c., vast quantities of nitrous salts are obtained by artificial arrangements called *nitrieries*, or nitre-beds. Very little nitrate of potash, indeed, is obtained in the first place; but the nitrates of lime and magnesia, which being deliquescent, remain in the nitrous earths in a semi-liquid state. The operation of converting these salts into good nitre is often sufficiently complex, in consequence of the presence of several muriates, which are difficult to eliminate.

The following instructions have been given by the consulting committee of *poudres et salpêtres* in France, for the construction of their *nitrières artificielles*. The permeability of the materials to the atmospherical air, being found to be as indispensable as is the presence of a base to fix the nitric acid at the instant of its formation, the first measure

is to select a light friable earth, containing as much carbonate of lime or old mortar-rubbish as possible; and to interstratify it with beds of dung, five or six inches thick, till a considerable heap be raised in the shape of a truncated pyramid, which should be placed under an open shed, and kept moist by watering it from time to time. When the whole appears to be decomposed into a kind of mould, it is to be spread under sheds in layers of from two to three feet thick; which are to be watered occasionally with urine and the drainings of dunghills, taking care not to soak them too much, lest they should be rendered impermeable to the air, though they should be always damp enough to favour the absorption and mutual action of the atmospherical gases. Moist garden mould affords an example of the physical condition most favourable to nitro-beds. The compost should be turned over, and well mixed with the spade once at least in every fortnight, and the sides of the shed should be partially closed; for although air be essential, wind is injurious, by carrying off the acid vapours, instead of allowing them to rest incumbent upon, and combine with, the bases. The chemical reaction is slow and successive, and can be made effective only by keeping the agents and materials in a state of quiescence. The whole process lasts two years; but since organic matters would yield in the lixiviation several soluble substances detrimental to the extraction of saltpetre, they must not be added during the operations of the latter six months; nor must anything except clear water be used for watering during this period: as the end of which the whole organic ingredients of the beds will be totally decomposed. Where dung is not sufficiently abundant for the above stratifications, a nitre-bed should be formed in a stable with friable earth, covered with a layer of litter; after four months the litter is to be lifted off, the earth is to be turned over, then another layer of fresh earth, 8 or 9 inches thick, is to be placed over it and a layer of the old and fresh litter over all. At the end of other four months, this operation is to be repeated; and in the course of a year the whole is ready to be transferred into the regular nitre-beds under a shed as above described. Such are the laborious and disagreeable processes practised by the peasants of Sweden, each of whom is bound by law to have a nitre-bed, and to furnish a certain quantity of nitre to the state every year. His *nitriary* commonly consists of a small hut built of boards, with a bottom of rammed clay, covered by a wooden floor, upon which is spread a mixture of ordinary earth with calcareous sand or marl, and lixiviated wood-ashes. This mixture is watered with stable urine, and its surface is turned over once a week in summer, and once a fortnight in winter. In some countries, walls 2 or 3 feet thick, and 6 or 7 high, are raised with the nitrifying compost, interspersed with weeds and branches of trees, in order at once to bind them together, and to favour the circulation of air. These walls are thatched with straw; they are placed with one of their faces in the direction of the rains; and must be moistened with water not rich in animal matter. One side of the wall is upright and smooth; while the other is sloped or terraced, to favour the admission of humidity into their interior. The nitre eventually forms a copious efflorescence upon the smooth side, whence it may be easily scraped off.

M. Longchamp, convinced that organic matters are a useless expense, and not in the least essential to nitrification, proposes to establish nitre-beds where fuel and labour are cheapest, as amidst forests, choosing as dry and low a piece of ground as possible, laying them out upon a square space of about 1000 feet in each side, in the middle of which the graduation-house may be built, and alongside of it sheds for the evaporation furnaces and pans. Upon each of the four sides the *nitrifying* sheds are to be erected, 150 feet long by 30 feet wide, where the lixiviation would be carried on, and whence the water would be conducted in gutters to the graduation-house. The sheds are to be closed at the sides by walls of *pisé*, and covered with thatch. No substance is so favourable to nitrification as the natural stony concretion known under the name of lime-tuf. In Touraine, where it is used as a building stone, the saltpetre makers re-establish the foundations of old houses at their own expense, provided they are allowed to carry off the old tuf, which owes its nitrifying properties, not only to its chemical nature, but to its texture, which being of a homogeneous porosity permits elastic fluids and vapours to pass through it freely in all directions. With the rough blocks of such tuf, walls about 20 inches thick, and moderately high, are to be raised, upon the principles above prescribed; in the absence of tuf, porous walls may be raised with a mixture of arable soil, sand, and mortar-rubbish, chalk or rich marl. The walls ought to be kept moist.

In France, the greater part of the indigenous saltpetre is obtained by lixiviating the mortar-rubbish of old buildings, especially of those upon the ground-floor, and in sunk cellars, which are by law reserved for this purpose. The first object of the manufacturer is then to ascertain the richness of his materials in nitrous salts, to see if they be worth the trouble of working; and this point he commonly determines merely by their saline, bitter, and pungent taste, though he might readily have recourse to the far surer criteria of lixiviation and evaporation. He next pounds them coarsely, and puts them into large casks open at top, and covered with straw at bottom; which are

placed in three successive levels. Water is poured into the casks till they are full, and after 12 hours' digestion it is run off, loaded with the salts, by a spigot near the bottom. A fresh quantity of water is then added, and drawn off after an interval of four hours; even a third and fourth lixiviation are had recourse to; but these weak liquors are reserved for lixiviating fresh rubbish. The contents of the casks upon the second and third lower levels are lixiviated with the liquors of the upper cask, till the lyes indicate from 12 to 14 degrees of Baumé's hydrometer. They are now fit for evaporating to a greater density, and of then receiving the dose of wood-ashes requisite to convert the materials of lime and magnesia into nitrate of potash, with the precipitation of the carbonates of magnesia and lime. The solution of nitre is evaporated in a copper pan, and as it boils, the scum which rises to the surface must be diligently skimmed off into a cistern alongside. Muriate of soda being hardly more soluble in boiling than in cold water, separates during the concentration of the nitre, and is progressively removed with cullender-shaped ladles. The fire is withdrawn whenever the liquor has acquired the density of 80° B.; it is allowed to settle for a little while, and is then drawn off, by a lead syphon adjusted some way above the bottom, into iron vessels, to cool and crystallize. The crystals thus obtained are set to drain, then re-dissolved and re-crystallized. The further purification of nitre is fully described under the article GUNPOWDER.

The annual production of saltpetre in France, by the above-described processes, during the wars of the Revolution, amounted to 2000 tons (2 millions of kilogrammes) of an article fit for the manufacture of gunpowder; of which seven-twentieths were furnished by the saltpetre works of Paris alone.

Nitrate of potash crystallizes in six-sided prisms, with four narrow and two broad faces: the last being terminated by a dihedral summit, or two-sided acumination; they are striated lengthwise, and have fissures in their long axis, which are apt to contain mother water. The spec. gravity of nitre varies from 1.93 to 2.00. It possesses a cooling, bitterish-pungent taste, is void of smell, permanent in the air when pure, fuses at a heat of about 662, into an oily-looking liquid, and concretes upon cooling into a solid mass, with a coarsely radiating fracture. This has got the unmeaning names of sal-prunelle and mineral crystal. At a red heat, nitre gives out at first a great deal of pretty pure oxygen gas; but afterwards nitrous acid fumes, while potash remains in the retort. It is soluble in 7 parts of water at 32°; in about 3½ at 60° F., in less than half a part at 194°, and in four-tenths at 212°. It is very slightly soluble in spirit of wine, and not at all in absolute alcohol. It causes a powerful deflagration when thrown upon burning coals; and when a mixture of it with sulphur is thrown into a red-hot crucible, a very vivid light is emitted. Its constituents are, 46.55 potash, and 53.45 nitric acid.

Nitre is applied to many purposes:—1. to the manufacture of gunpowder; 2. to that of sulphuric acid; 3. to that of nitric acid, though nitrate of soda or cubic nitre has lately superseded this use of it to a considerable extent; 4. to that of flint-glass; 5. it is used in medicine; 6. for many chemical and pharmaceutical preparations; 7. for procuring by deflagration with charcoal or cream of tartar, pure carbonate of potash, as also black and white fluxes; 8. for mixing with salt in curing butcher meat; 9. in some countries for sprinkling in solution upon grain, to preserve it from insects; 10. for making fireworks. See FIRE-WORKS.

LANDINGS, DELIVERIES, AND STOCKS OF SALTPETRE.

| | | Landed. | Delivered. | Stock 1st January. |
|--------------|------|---------|------------|--------------------|
| | | Tons. | Tons. | Tons. |
| In December | 1851 | 415 | 551 | — |
| | 1850 | 607 | 671 | — |
| In 12 Months | 1851 | 7,764 | 7,859 | 2,321 |
| | 1850 | 9,661 | 10,327 | 2,416 |
| | 1849 | 9,997 | 8,774 | 3,082 |
| | 1848 | 11,034 | 9,864 | 1,794 |

Prices.—Bengal, 25s. to 28s. 6d. per cwt.; Madras, 24s. to 25s.

NITRATE OF SILVER (*Nitrate d'argent*, Fr.; *Silbersalpeter*, Germ.); is prepared by saturating pure nitric acid of specific grav. 1.25 with pure silver, evaporating the solution, and crystallizing the nitrate. When the drained crystals are fused in a platina capsule, and cast into slender cylinders in silver moulds, they constitute the lunar caustic of the surgeon. This should be white, and unchangeable by light. It is deliquescent in moist air. The crystals are colourless transparent 4 and 6 sided tables;

they possess a bitter, acrid, and most disagreeable metallic taste; they dissolve in their own weight of cold, and in much less of hot water; are soluble in four parts of boiling alcohol, but not in nitric acid; they deflagrate on red-hot coals, like all the nitrates; and detonate with phosphorus when the two are struck together upon an anvil. They consist of 68·2 of oxide, and 31·8 of acid. Nitrate of silver, when swallowed, is a very energetic poison: but it may be readily counteracted, by the administration of a dose of sea-salt, which converts the corrosive nitrate into the inert chloride of silver. Animal matter, immersed in a weak solution of neutral nitrate of silver, will keep unchanged for any length of time: and so will polished iron or steel. Nitrate of silver is such a delicate reagent of hydrochloric or muriatic acid, as to show by a sensible cloud, the presence of one 113 millionth part of it, or one 7 millionth part of sea-salt in distilled water. It is much used under the name of indelible ink, for writing upon linen with a pen; for which purpose one drachm of the fused salt should be dissolved in three quarters of an ounce of water, adding to the solution as much water of ammonia as will re-dissolve the precipitated oxide, with sap-green to colour it, and gum-water to make the volume amount to one ounce. Traces written with this liquid should be first heated before a fire to expel the excess of ammonia, and then exposed to the sun-beam to blacken. Another mode of using nitrate of silver as an indelible ink, is to imbue the linen first with solution of carbonate of soda, to dry the spot, and write upon it with a solution of nitrate of silver, thickened with gum, and tinted with sap-green.

NITRATE OF SODA, Cubical Nitre (*Nitrate de soude*, Fr.; *Würfelsalpeter*, Germ.); occurs under the nitre upon the lands in Spain, India, Chile, and remarkably in Peru, in the districts of Atacama and Taracapa, where it forms a bed several feet thick. It appears in several places upon the surface, and extends over a space of more than forty leagues, approaching near to the frontiers of Chile. It is sometimes efflorescent, sometimes crystallised, but oftener confusedly mixed with clay and sand. This immensely valuable deposit is only three days' journey from the port of Concepcion in Chile, and from Iquique, another harbour situated in the southern part of Peru.

Nitrate of soda may be artificially prepared by neutralising nitric acid with soda, and crystallizing the solution. It crystallizes in rhomboids, has a cooling, pungent, bitterish taste, less disagreeable than nitre; it becomes moist in the air; dissolves in 3 parts of water at 60° F., in less than 1 part of boiling water; deflagrates more slowly than nitre, and with an orange yellow flame. It consists, in its dry state, of 36·6 soda and 63·4 nitric acid; but its crystals contain one prime equivalent of water; hence they are composed of, acid 56·84, base 33·68, water 9·47.

It is susceptible of the same applications as nitre, with the exception of making gunpowder; for which it is not adapted, on account of its deliquescent property.

We extract the following from a paper read before the Royal Geographical Society of London, on the 28th of April, 1851, entitled *Observations on the Geography of Southern Peru, &c. &c.* by W. Bollaert, Esq. F.R.G.S.

"The existence of this valuable substance in the province of Tarapaca has been known in Europe about a century. In 1820, some of it was sent to England, but the duty then being so high, it was thrown overboard. In 1827, efforts were unsuccessfully made by an English house to export it. In 1830, a cargo was sent to the United States; it was found unsaleable there, and a part of it taken to Liverpool, but was returned as unsaleable in England. A cargo was then sent to France, and in 1831, another to England, when it became better known, and sold as high as 30s. to 40s. the cwt. Its price has varied very much; present quotations (1851) about 15s. Since 1831 to 1852, the exports of nitrate from Iquique have been 5,293,478 quintals, equal to about 239,860 tons, some of it being used as a fertilizer of land, some in the manufacture of nitric acid. The principal deposits of nitrate of soda, yet known, are found on the western side of the Pampa de Tamarugal, commencing immediately where the level plain ceases, and on the sides of some of the ravines running from the Pampa towards the coast and in some of the hollows of the mountains. The nitrate has not been found nearer to the coast than 18 miles, and looks as if it gradually transferred itself into salt as it approached the coast. The officinos or refining works are divided into northern and southern Saletres; the old Saletres being about the centre of the former, and La Nueva Noria that of the latter; there are in all about 100 officinos. The nitrate deposits commence about Tiliuche, and extend south near to Quillaguas with interruptions of deposits of common salt. The nitrate calciche grounds vary in breadth; the average may be 500 yards, and in places 7 to 8 feet thick, and sometimes quite pure. In the ravines and hollows before mentioned, the nitrate is found on their shelving sides; the hollows look like dried-up cakes, and are covered with salt 2 to 3 feet thick, and on the margins there is nitrate of soda oftentimes going down to some depth; in others there is a hard dry crust upon it, occasionally 4 feet thick. The nitrate calciche formed under this

crust is in thin layers, and so solid and pure as to be sought for, although the expense of blasting is very great.

"There are several varieties of the nitrate of soda calcche, the following being the principal.

"1. White, compact, containing 64 per cent.

"2. Yellow, occasioned by salts of iodine, 70 per cent.

"3. Grey compact, containing a little iron and a trace of iodine, 46 per cent.

"4. Grey crystalline, the most abundant variety, contains from 20 to 85 per cent., affording traces of iodine, with 1 to 8 per cent of earthy matter.

"5. White crystalline : this resembles the refined nitrate.

"All these contain common salt, sulphate and carbonate of soda, muriate of lime, and occasionally some borate of lime, as found under the nitrate beds: one variety of the latter, composed of boracic acid 49·5, soda 8·8, water 26·0, lime 15·7 = 100, may probably become of use in this country in glass-making, &c.

"Fragments of shells have been noticed with and under the nitrate bed: this may account in some measure for the lime in the borate and muriate. Mr. Blake mentions that 200 feet above the Pampa, (which is 3500 above the level of the sea), near to Los Saletres del porté, 'limestone containing shells rises from a bed consisting of pebbles and shells cemented together by salt and nitrate of soda; part of the shells are decomposed, whilst others are perfect in form, and like those now still found lying on the rocks in the inlets of the sea.'

"The rough nitrate of soda is broken into small pieces, put into boilers, water introduced and the whole boiled; the nitrate is held in solution, while the earthy matter, salt, phosphates, &c., are separated and fall to the bottom of the vessel: the saturated solution of nitrate is let into a reservoir, where it deposits any remaining earthy matter; the clear liquor is run into shallow troughs, exposed to the sun, crystallization takes place, containing only 2 to 3 per cent. of impurities, and is ready to be conveyed to the coast for exportation. The Pampa de Tamarugal contains sufficient nitrate of soda for the consumption of Europe for ages; the desert of Atacama yields it; it has also been met with on the Andes and in the Eastern plains.

"Imports into the United Kingdom from Chili and Peru of Cubic Nitre, compiled from Official Sources.

| Years. | Chili. | Peru. |
|--------|--------|--------|
| | Tons. | Tons. |
| 1832 | 296 | 498 |
| 1833 | 440 | 583 |
| 1834 | 2,521 | 1,303 |
| 1835 | 1,326 | 2,068 |
| 1836 | 2,183 | 1,625 |
| 1837 | 1,355 | 4,345 |
| 1838 | 1,091 | 2,099 |
| 1839 | 1,488 | 2,132 |
| 1840 | 2,651 | 4,696 |
| 1841 | 1,188 | 3,546 |
| 1842 | 5,048 | 4,239 |
| 1843 | 5,011 | 1,797 |
| 1844 | 1,523 | 5,531 |
| 1845 | 1,437 | 6,705 |
| 1846 | 2,669 | 6,752 |
| 1847 | 1,834 | 13,506 |
| 1848 | 1,676 | 8,425 |
| 1849 | 4,154 | 8,876 |
| 1850 | 1,150 | 10,740 |

NITRATE OF STRONTIA. (*Nitrate de strontiane*, Fr.; *Salpetersäurer strontian*, Germ.) This salt is usually prepared from the sulphuret of strontium, obtained by decomposing sulphate of strontia with charcoal, by strong ignition of the mixed powders in a crucible. This sulphuret being treated with water, and the solution being filtered, is to be neutralized with nitric acid, as indicated by the test of turmeric paper; care being taken to avoid breathing the noxious sulphuretted hydrogen gas, which is copiously disengaged. The neutral nitrate being properly evaporated and set aside, affords colourless, transparent, slender, octahedral crystals. It has a cooling, yet somewhat acrid taste; is soluble in 5 parts of cold, and in one half part of boiling water,

as also in alcohol; is permanent in the air, deflagrates upon burning coals, gives off oxygen when calcined, and leaves caustic strontia. The salt consists of 48.9 strontia and 51.1 nitric acid. That salt is anhydrous; but there is another variety of it, which contains nearly 40 per cent. of water of crystallization, which occurs in large octahedrons. This is preferred for fire-works, because by efflorescence it is easily obtained in a fine powder, which mixes more intimately with the chlorate of potash and charcoal, for the composition of the brilliant red fires, now so much admired in theatrical conflagrations.

NITRIC ACID, *Aquafortis* (*Acide nitrique*, Fr.; *Salpetersäure*, Germ.); exists, in combination with the bases, potash, soda, lime, magnesia, in both the mineral and vegetable kingdoms. This acid is never found insulated. It was distilled from saltpetre so long ago as the 13th century, by igniting that salt, mixed with copperas or clay, in a retort. Nitric acid is generated when a mixture of oxygen and nitrogen gases, confined over water or an alkaline solution, has a series of electrical explosions passed through it. In this way the salubrious atmosphere may be converted into corrosive aquafortis. When a little hydrogen is introduced into the mixed gases, standing over water, the chemical agency of the electricity becomes more intense, and the acid is more rapidly formed from its elements, with the production of some nitrate of ammonia.

Nitric acid is usually made on the small scale by distilling, with the heat of a sand-bath, a mixture of 3 parts of pure nitre, and 2 parts of strong sulphuric acid, in a large glass retort, connected by a long glass tube with a globular receiver surrounded by cold water. By a well regulated distillation, a pure acid, of specific gravity 1.500, may be thus obtained, amounting in weight to about two-thirds of the nitre employed. To obtain easily the whole nitric acid, equal weights of nitre and concentrated sulphuric acid may be taken; in which case but a moderate heat need be applied to the retort. The residuum will be bisulphate of potash. When only the single equivalent proportion of sulphuric acid is used, namely 48 parts for 100 of nitre, a much higher heat is required to complete the distillation, whereby more or less of the nitric acid is decomposed, while a compact neutral sulphate of potash is left in the retort, very difficult to remove by solution in water, and therefore apt to destroy the vessel.

Aquafortis is manufactured upon the great scale in iron pots or cylinders of the same construction as I have described under muriatic acid. The more concentrated the sulphuric acid is, the less corrosively will it act upon the metal; and it is commonly used in the proportion of one part by weight to two of nitre. The salt being introduced into the cool retort, and the lid being luted tight, the acid is to be slowly poured in through the aperture *f*, fig. 983; while the aperture *g* is connected by a long glass tube with a range of balloons inserted into each other, and laid upon a sloping bed of sand. The bottle *i*, with 3 tubulures partly filled with water, which is required for condensing muriatic acid gas, must, for the present purpose, be replaced by a series of empty receivers, either of glass or salt-glazed stoneware. The cylinders should be only half filled, and be worked off by a gradually raised heat.

Commercial aquafortis is very generally contaminated with sulphuric and muriatic acids, as also with alkaline sulphates and muriates. The quantity of these salts may be readily ascertained by evaporating in a glass capsule a given weight of the aquafortis; while that of the muriatic acid may be determined by nitrate of silver; and of sulphuric acid, by nitrate of baryta. Aquafortis may be purified, in a great measure, by re-distillation at a gentle heat; rejecting the first liquid which comes over, as it contains the chlorine impregnation; receiving the middle portion as genuine nitric acid; and leaving a residuum in the retort, as being contaminated with sulphuric acid.

Since nitrate of soda has been so abundantly imported into Europe from Peru, it has been employed by many manufacturers in preference to nitre for the extraction of nitric acid, because it is cheaper, and because the residuum of the distillation, being sulphate of soda, is more readily removed by solution from glass retorts, when a range of these set in a gallery furnace is the apparatus employed. Nitric acid of specific gravity 1.47 may be obtained colourless; but by further concentration a portion of it is decomposed, whereby some nitrous acid is produced, which gives it a straw-yellow tinge. At this strength it exhales white or orange fumes, which have a peculiar, though not very disagreeable smell; and even when largely diluted with water, it tastes extremely sour. The greatest density at which it can be obtained is 1.51 or perhaps 1.52, at 60° F., in which state, or even when much weaker, it powerfully corrodes all animal, vegetable, and most metallic bodies. When slightly diluted it is applied, with many precautions, to silk and woollen stuffs, to stain them of a bright yellow hue. See CALICO-PRETTING; page 935.

In the dry state, as it exists in nitre, this acid consists of 26.15 parts by weight of azote, and 73.85 of oxygen; or of 2 volumes of the first gas, and 5 volumes of the second.

When of specific gravity 1.5, it boils at about 210° Fahr.; of 1.45, it boils at about 240°; of 1.42, it boils at 253°; and of 1.40, at 246° F. If an acid stronger than 1.420 be distilled in a retort, it gradually becomes weaker; and if weaker than 1.42, it gradually becomes stronger, till it assumes that standard density. Acid of specific gravity

1.485 has no more action upon tin than water has, though when either stronger or weaker it oxidizes it rapidly, and evolves fumes of nitrous gas with explosive violence. In my two papers upon nitric acid published in the fourth and sixth volumes of the Journal of Science (1818 and 1819), I investigated the chemical relations of these phenomena. Acid of 1.420 consists of 1 atom of dry acid, and 4 of water; acid of 1.485, of 1 atom of dry acid, and 2 of water; the latter compound possesses a stable equilibrium as to chemical agency; the former as to calorific. Acid of specific gravity 1.334, consisting of 7 atoms of water, and 1 of dry acid, resists the decomposing agency of light. Nitric acid acts with great energy upon most combustible substances, simple or compound, giving up oxygen to them, and resolving itself into nitrous gas, or even azote. Such is the result of its action upon hydrogen, phosphorus, sulphur, charcoal, sugar, gum, starch, silver, mercury, copper, iron, tin, and most other metals.

From muriatic to nitric acid the transmission is easy, though nitric acid is never obtained as the waste product of any chemical operation. Its manufacture is invariably the primary object of the process by which it is procured. The ordinary method consists in heating together, in a distillatory apparatus, a mixture of nitrate of soda or potash with sulphuric acid. In this way, the sulphuric acid unites with the soda or potash, as the case may be, forming commercial products, also salt cake and sal-enix; whilst the nitric acid combines with the water of the sulphuric acid, and, passing away under the influence of the heat, is condensed in the receiver of the apparatus. A decomposition of this kind is sometimes denominated a simple decomposition; but in reality it is not so, as the transfer of the water completes the cycle of elective affinity.

A Table of Nitric Acid, by Dr. Ure.

| Specific gravity. | Liq. Acid in 100. | Dry acid in 100. | Specific gravity. | Liq. Acid in 100. | Dry acid in 100. | Specific gravity. | Liq. Acid in 100. | Dry acid in 100. | Specific gravity. | Liq. Acid in 100. | Dry Acid in 100. |
|-------------------|-------------------|------------------|-------------------|-------------------|------------------|-------------------|-------------------|------------------|-------------------|-------------------|------------------|
| 1.5000 | 100 | 79.700 | 1.4189 | 75 | 59.775 | 1.2947 | 50 | 39.850 | 1.1403 | 25 | 19.925 |
| 1.4980 | 99 | 78.903 | 1.4147 | 74 | 58.978 | 1.2887 | 49 | 39.053 | 1.1345 | 24 | 19.128 |
| 1.4960 | 98 | 78.106 | 1.4107 | 73 | 58.181 | 1.2826 | 48 | 38.256 | 1.1286 | 23 | 18.331 |
| 1.4940 | 97 | 77.309 | 1.4065 | 72 | 57.384 | 1.2765 | 47 | 37.459 | 1.1227 | 22 | 17.534 |
| 1.4910 | 96 | 76.512 | 1.4023 | 71 | 56.587 | 1.2705 | 46 | 36.662 | 1.1168 | 21 | 16.737 |
| 1.4880 | 95 | 75.715 | 1.3978 | 70 | 55.790 | 1.2644 | 45 | 35.865 | 1.1109 | 20 | 15.940 |
| 1.4850 | 94 | 74.918 | 1.3945 | 69 | 54.993 | 1.2583 | 44 | 35.068 | 1.1051 | 19 | 15.143 |
| 1.4820 | 93 | 74.121 | 1.3882 | 68 | 54.196 | 1.2523 | 43 | 34.271 | 1.0993 | 18 | 14.346 |
| 1.4790 | 92 | 73.324 | 1.3833 | 67 | 53.399 | 1.2462 | 42 | 33.474 | 1.0935 | 17 | 13.549 |
| 1.4760 | 91 | 72.527 | 1.3783 | 66 | 52.602 | 1.2402 | 41 | 32.677 | 1.0878 | 16 | 12.752 |
| 1.4730 | 90 | 71.730 | 1.3732 | 65 | 51.805 | 1.2341 | 40 | 31.880 | 1.0821 | 15 | 11.955 |
| 1.4700 | 89 | 70.933 | 1.3681 | 64 | 51.008 | 1.2277 | 39 | 31.083 | 1.0764 | 14 | 11.158 |
| 1.4670 | 88 | 70.136 | 1.3630 | 63 | 50.211 | 1.2212 | 38 | 30.286 | 1.0708 | 13 | 10.361 |
| 1.4640 | 87 | 69.339 | 1.3579 | 62 | 49.414 | 1.2148 | 37 | 29.489 | 1.0651 | 12 | 9.564 |
| 1.4600 | 86 | 68.542 | 1.3529 | 61 | 48.617 | 1.2084 | 36 | 28.692 | 1.0595 | 11 | 8.767 |
| 1.4570 | 85 | 67.745 | 1.3477 | 60 | 47.820 | 1.2019 | 35 | 27.895 | 1.0540 | 10 | 7.970 |
| 1.4530 | 84 | 66.948 | 1.3427 | 59 | 47.023 | 1.1958 | 34 | 27.098 | 1.0485 | 9 | 7.173 |
| 1.4500 | 83 | 66.151 | 1.3376 | 58 | 46.226 | 1.1895 | 33 | 26.301 | 1.0430 | 8 | 6.376 |
| 1.4460 | 82 | 65.354 | 1.3323 | 57 | 45.429 | 1.1833 | 32 | 25.504 | 1.0375 | 7 | 5.579 |
| 1.4424 | 81 | 64.557 | 1.3270 | 56 | 44.632 | 1.1770 | 31 | 24.707 | 1.0320 | 6 | 4.782 |
| 1.4385 | 80 | 63.760 | 1.3216 | 55 | 43.835 | 1.1709 | 30 | 23.900 | 1.0267 | 5 | 3.985 |
| 1.4346 | 79 | 62.963 | 1.3163 | 54 | 43.038 | 1.1648 | 29 | 23.113 | 1.0212 | 4 | 3.188 |
| 1.4306 | 78 | 62.166 | 1.3110 | 53 | 42.241 | 1.1587 | 28 | 22.316 | 1.0159 | 3 | 2.391 |
| 1.4269 | 77 | 61.369 | 1.3056 | 52 | 41.444 | 1.1526 | 27 | 21.519 | 1.0106 | 2 | 1.594 |
| 1.4228 | 76 | 60.572 | 1.3001 | 51 | 40.647 | 1.1465 | 26 | 20.722 | 1.0053 | 1 | 0.797 |

It has been proposed, and even carried into practice, to decompose nitrate of soda by the action of boracic acid, so as to produce baborate of soda, or borax, and thus render the nitric acid a secondary product. The success of this process depends, however, upon a circumstance of a somewhat curious kind. Strong nitric acid is much more volatile than weak acid; and hence it is more easily expelled from its combination with soda in a concentrated than in a diluted form. Now, boracic acid has 3 atoms of water in its crystallized condition; therefore, if we take 2 atoms of this acid, we have 6 atoms of water to unite with the 1 atom of nitric acid capable of being disengaged from nitrate of soda; whereas this quantity of nitric acid needs at most but 2 atoms. The secret, therefore, is to dry the boracic acid in the first instance, so as to get rid of the surplus water; and this is easily done at a temperature of 212° Fahr., at which two-thirds of

the water readily leave the boracic acid, and thus afford a mono-hydrated compound, 2 atoms of which contain precisely the amount of water needed for one atom of nitric acid, and also of the boracic acid requisite for the production of the biborate of soda. There are some peculiarities connected with the application of the necessary temperature; but they are of less importance. The biborate of soda is afterwards dissolved in hot water, and crystallized. This process has been patented in France within the last few years, by a M. Mallet, of Paris. One of the most extensive uses of nitric acid, and for which, indeed, it is chiefly fabricated, is the manufacture of oxalic acid.

Nitric Acid, anhydrous.—By treating nitrate of silver with perfectly dry chlorine, M. Deville has succeeded in isolating anhydrous nitric acid, the existence of which was demonstrated by numerous analyses. This beautiful substance is obtained in colourless crystals, which are perfectly brilliant and limpid, and may be procured of considerable size; when they are slowly deposited in a current of gas rendered very cold, their edges are a centimetre in length. These crystals are prisms of 6 faces, which appear to be derived from a right prism with a rhombic base. They melt at a temperature not much exceeding 85.5 Fahr.; their boiling point is about 113°; and at 50° the tension of this substance is very considerable. In contact with water it becomes very hot, and dissolves in it without imparting colour, and without disengaging any gas; it then produces with barytes the nitrate of that base. When heated, its decomposition appears to commence nearly at its boiling point. This circumstance is an obstacle to the determination of the density of its vapour by the process of M. Dumas.

The process by which M. Deville obtained anhydrous nitric acid is very simple; but the readiness with which it penetrates tubes of caoutchouc renders it necessary to unite all the pieces of the apparatus by melting them. The following is the process:—The author employs a U-shaped tube capable of containing 500 gr. of nitrate of silver dried in the apparatus at 356° Fahr. in a current of dry carbonic acid gas. Another very large U tube is connected with this, and to its lower part is attached a small spherical reservoir; it is in this reservoir that a liquid is deposited which always forms during the operation, and which is exclusively volatile (nitrous acid?). The tube containing the nitrate of silver is immersed in water covered with a thin stratum of oil, and heated by means of a spirit lamp communicating with a reservoir at a constant level. The chlorine issues from a glass gasometer, and its displacement is effected by a slow and constant flow of concentrated sulphuric acid. The chlorine must afterwards pass over chloride of lime, and then over pumice-stone moistened with sulphuric acid. At common temperatures no effect appears to be produced. The nitrate of silver must be heated to 203° Fahr., the temperature being then quickly reduced to 136° or 154°, but not lower. At the commencement, hyponitrous acid, distinguishable by its colour and ready condensation, is produced; and when the temperature has reached its lowest point, the production of crystals begins, and they soon choke the receiver, cooled to 6° below zero; they are always deposited upon that part of the receiver which is not immersed in the freezing mixture, and M. Deville states that ice alone is sufficient to occasion their formation.

The gases are coloured, and the small sphere of the cooled tube contains a small quantity of liquid, which must be taken from the apparatus before the nitric acid is removed to another vessel; this latter operation is readily effected by replacing the current of chlorine by one of carbonic acid. The condenser is then to be no longer cooled, and the vessel for receiving the crystals is to be immersed in a freezing mixture; this is fastened to the producing apparatus by means of a caoutchouc tube furnished with amianthus. The chlorine should pass very slowly, at the rate of about 3 or 4 litres in 24 hours. All the gas, however, is not absorbed by the nitrate of silver. Oxygen is evolved, the volume of which appears to be equal to that of the chlorine employed. An apparatus thus constructed operates day and night without watching, care being however taken to renew the sulphuric acid which displaces the chlorine, the spirit of the lamp, and the ingredients of the freezing mixture.

The author states that he shall forward hereafter a more complete memoir, in which he will describe the chemical properties of the anhydrous nitric acid, and detail the results of his researches on the action of chlorine and hypochlorous acid on the salts of silver.

NITROGEN, DEUTOXIDE OF; *Nitrous gas, Nitric oxide (Deutoxide d'azote, Fr.; Stickstoffoxyd, Germ.)*; is a gaseous body which may be obtained by pouring upon copper or mercury, in a retort, nitric acid of moderate strength. The nitrous gas comes over in abundance without the aid of heat, and may be received over water freed from air, or over mercury, in the pneumatic trough. It is elastic and colourless; what taste and smell it possesses are unknown, because the moment it is exposed to the mouth or nostrils, it absorbs atmospherical oxygen, and becomes nitrous or nitric acid. Its specific gravity is 1.0393, or 1.04; whence 100 cubic inches weigh 36.66 gr. Water condenses not more than $\frac{1}{10}$ of its volume of this gas. It extinguishes animal life, and

the flame of many combustibles; but of phosphorus well kindled, it brightens the flame in a most remarkable degree. It consists of 47 parts of nitrogen gas, and 53 of oxygen gas, by weight; and of equal parts in bulk, without any condensation; so that the specific gravity of the deutoxide of nitrogen is the arithmetical mean of the two constituents. The constitution of this gas, and the play of affinities which it exercises in the formation of sulphuric acid, are deeply interesting to the chemical manufacturer.

The *Hyponitrous acid* (*Salpetrigesäure*, Germ.), like the preceding compound, deserves notice here, on account of the part it plays in the conversion of sulphur into sulphuric acid, by the agency of nitre. It is formed by mingling four volumes of deutoxide of nitrogen with one volume of oxygen; and appears as a dark orange vapour, which is condensable into a liquid at a temperature of 4° below zero, Fahr. When distilled, this liquid leaves a dark yellow fluid. The pure hyponitrous acid consists of 37.12 nitrogen, and 62.88 oxygen; or of two volumes of the first, and three of the second. Water converts it into nitric acid and deutoxide of nitrogen; the latter of which escapes with effervescence. This acid oxidises most combustible bodies with peculiar energy; and though its vapour does not operate upon dry sulphurous acid, yet, through the agency of steam, it converts it into sulphuric acid, itself being simultaneously transformed into deutoxide of nitrogen; ready to become hyponitrous acid again, and to perform a circulating series of important metamorphoses. See SULPHURIC ACID.

NITROGEN, PREPARATION OF. This process is founded on the decomposition of nitrate of ammonia, which, as is already known, is resolved into nitrogen and water under the influence of heat; but as this salt is difficult to prepare, I replace it by a mixture of an alkaline nitrate of potash and sal ammoniac, a mixture which contains the elements of nitrite of ammonia and chloride of potassium. The best method of obtaining the nitrite of potash in a convenient state is to pass nitrous acid gas, formed by the action of 10 parts of nitric acid on one part of starch, through a solution of caustic potash having a sp. gr. 1.38, until the solution acquires an acid reaction; and then to add a little caustic potash, so as to render it distinctly alkaline. As the solution thus prepared does not undergo alteration from keeping, it may be held in readiness; and when the nitrogen is required, it is only necessary to mix one volume of the above solution with three volumes of a concentrated solution of sal-ammoniac, and to heat the mixture in a flask. The disengagement of the gas takes place almost immediately, and continues with great regularity.

As it is necessary, in order to make the gas pure, that the nitrate should be alkaline, there will be a disengagement at the same time of a little ammonia, but this is of no consequence; if the nitrogen be required completely free from ammonia, it is sufficient to pass the gas through a vessel containing water acidulated with a little sulphuric acid.

The following are the experiments by which I have satisfied myself of the purity of the nitrogen thus obtained:—

1. After freeing the gas from ammonia as above described, it was conveyed into a tube containing a mixture of zinc, sulphuric acid, and water; into the presence, therefore, of nascent hydrogen. The experiment was continued for some time, and when concluded I could not detect a trace of ammonia in the solution.

The solution was also negative on testing it with sulphate of iron and dilute sulphuric acid.

2. I placed in a glass tube, such as is used for organic analysis, a determined quantity of copper recently reduced by hydrogen, and exposed this for half an hour to the action of a red heat and of a current of the nitrogen washed and subsequently dried by passing it through pumice-stone wetted with oil of vitriol; taking at the same time the precaution not to heat the tube until all the atmospheric air had been displaced by the nitrogen. This experiment was repeated several times, without any alteration being observed either in the exterior appearance of the copper or in its weight.

NITROGEN GAS, or AZOTE (Eng. and Fr.; *Stickstoffgas*, Germ.); constitutes about 79 hundredths of the bulk of the atmospheric air; it is copiously disengaged from several mineral springs, as from the natural basins of hot water which supply the baths of Leuk, near the Gemmi in Switzerland, and from other springs, in the Pyrenees, in Ceylon, South and North America, &c. It exists also in flesh and most animal substances, as well as in some vegetable products, being one of their essential constituents. When phosphorus is burnt within a jar filled with air, standing over water in the pneumatic trough, it consumes or absorbs the oxygen, and leaves nitrogen, which may be rendered pure by agitation with water. By exposing nitrite of ammonia to heat in a retort, nitrogen comes over alone in great abundance; for the hydrogen of the ammonia is sufficient to saturate the oxygen of the acid, and to convert it into water; while the nitrogen of both constituents is set at liberty. By transmitting chlorine through water of ammonia, or digesting lean flesh in warm nitric acid, nitrogen may also be obtained. This permanently elastic gas is destitute of colour, taste, and smell; it has a specific gravity of

0.976, air being 1.000. Hence 100 cubic inches of it weigh 29.7 gr. It extinguishes all burning bodies, and when respired without oxygen is fatal to animal life.

NITROGEN, PROTOXIDE OF; *Nitrous oxide* (*Protoxide d'azote*, Fr.; *Stickstoffoxydul*, Germ.); is a gas which displays remarkable powers when breathed, causing in many persons unrestrained feelings of exhilaration, whence it has been called the laughing or intoxicating gas. It is prepared by exposing crystallized nitrate of ammonia to a heat of about 350° Fahr., in a glass retort. It is much denser than the air of the atmosphere, having a spec. grav. of 1.527; whence 100 cubic inches weigh 49.6 grains. It consists of 63.64 parts of nitrogen, and 36.36 of oxygen, by weight; or of two volumes of nitrogen and one volume of oxygen, condensed by reciprocal attraction into two volumes. It is colourless, and possesses all the mechanical properties of the atmosphere. Water previously freed from air absorbs its own volume of this gas; and thus affords a ready criterion for estimating its freedom from incondensable gases, as oxygen, nitrogen, and its deutoxide. Several combustibles burn in this gas with an enlarged blue and very vivid flame; and it relumes a taper, which has been blown out, provided its tip be redhot. By powerful pressure it may be liquefied. See GAS.

NITRO-MURIATIC ACID; *Aqua regia* (*Acide nitro-muriatique*, Fr.; *Salpeter-salzsäure*, *Königswasser*, Germ.); is the compound menstruum invented by the alchemists for dissolving gold. If strong nitric acid, orange-coloured by saturation with nitrous gas (deutoxide of azote), be mixed with the strongest liquid muriatic acid, no other effect is produced than might be expected from the action of nitrous acid of the same strength upon an equal quantity of water; nor has the mixed acid so formed any power of acting upon gold or platina. But if colourless aquafortis and ordinary muriatic acid be mixed together, the mixture immediately becomes yellow, and acquires the power of dissolving these two noble metals. When gently heated, pure chlorine gas rises from it, and its colour becomes deeper; when further heated, chlorine still rises, but now mixed with nitrous acid gas. If the process has been very long continued, till the colour becomes very dark, no more chlorine can be procured, and the liquor has lost the power of dissolving gold. It then consists of nitrous and muriatic acids. It appears, therefore, that aqua regia owes its peculiar properties to the mutual decomposition of the nitric and muriatic acids; and that water, chlorine, and nitrous acid gas are the results of that reaction. Aqua regia does not, strictly speaking, oxidize gold and platinum; it causes merely their combination with chlorine. It may be composed of very different proportions of the two acids; the nitric being commonly of specific gravity 1.34; the muriatic, of specific gravity 1.18 or 1.19. Sometimes 3 parts, and at others 6 parts of the muriatic acid are mixed with 1 of nitric; and occasionally muriate of ammonia, instead of muriatic acid, is added to nitric acid for particular purposes, as for making a solution of tin for the dyers. An aqua regia may also be prepared by dissolving nitre in muriatic acid.

NITROUS ACID (*Acide nitreux*, Fr.; *Salpetrige salpetersäure*, Germ.); may be procured by distilling, in a coated glass retort, perfectly dry nitrate of lead, into a glass receiver surrounded with a freezing mixture. The acid passes over in vapour, and condenses into a liquid; oxygen gas escapes through the safety tube; while oxide of lead remains in the bottom of the retort. Nitrous acid may also be obtained by distilling strong fuming nitric acid, at the lowest possible temperature, and rectifying what comes over. At 4° — zero, Fahr., this acid is colourless; at 32° it is wax yellow; at 60° it has an orange hue. It possesses a strong smell, has a very pungent, acid, sour taste, and a specific gravity of 1.42. It powerfully decomposes organic bodies, staining them yellow. It boils at 82° Fahr. with the disengagement of red or orange fumes. Its constituents are, 41.34 of hyponitrous acid, and 58.66 of anhydrous nitric acid; or ultimately, 30.68 nitrogen = 1 volume, and 69.32 oxygen = 2 volumes. In its other habitudes, it is quite analogous to hyponitrous acid.

A mixture of this double or compound acid with nitric acid constitutes the orange-brown fuming nitrous acid of the British apothecaries.

The hyponitrous and nitrous are two acids, remarkable for containing no water in their composition: being therefore *dry liquids*.

NOPAL, is the Mexican name of the plant *cactus opuntia*, upon which the cochineal insect breeds.

NUTMEG (*Muscade*, Fr.; *Muskatennus*, Germ.); is the fruit of the *myristica moschata*, a beautiful tree of the family of the *laurineæ* of Jussieu, which grows in the Molucca islands. All the parts of this tree are very aromatic: but only those portions of the fruit called mace and nutmeg are sent into the market. The entire fruit is a species of *drupa*, of an ovoid form, of the size of a peach, and furrowed longitudinally. The nutmeg is the innermost kernel, or seed, contained in a thin shell, which is surrounded by the mace; and this again is enclosed in a tough fleshy skin, which opening at the tip, separates into two valves. The nutmeg tree yields three crops annually; one in April, which is the best; one in August; and one in December.

Good nutmegs should be dense, and feel heavy in the hand. When they have been perforated by worms, they feel light, and though the holes have been fraudulently stopped, the unsound ones may be easily detected by this criterion.

Nutmegs afford two oily products. 1. Butter of nutmeg, vulgarly called oil of mace, is obtained in the Moluccas, by expression, from the fresh nutmegs, to the amount of 50 per cent. of their weight. It is a reddish yellow butter-like substance, interspersed with light and dark streaks, and possesses the agreeable smell and taste of the nutmeg, from the presence of a volatile oil. It consists of two fats; one reddish and soft, soluble in cold alcohol; another white and solid, soluble in hot alcohol. 2. The volatile oil is solid, or a *stereoptene*, and has been styled *Myristicine*.

Imported in 1850, 315,126 lbs.; in 1851, 358,320 lbs.; exported, 1850, 151,526 lbs., in 1851, 107,495 lbs.; retained for home consumption, 1850, 168,403 lbs., in 1851, 194,132 lbs.; duty received, 1850, 19,042*l.*, 1851, 21,913*l.*

NUT OIL. See OILS, UNCTUOUS.

NUX VOMICA, a poisonous nut, remarkable for containing the vegeto-alkali STRYCHNIA.

O.

OAK BARK. See TAN.

OATS (*Avoine*, Fr.; *Hafer*, Germ.) The composition of oats is less known than that of the other *Cerealia*. Vögel found that 100 parts of oats afforded 66 parts of flour or meal, and 34 parts of bran; but this proportion would depend upon the quality of the grain. The flour contains 2 parts of a greenish-yellow fat oil; 8·25 of bitterish sweet extractive; 2·5 of gum; 3·30 of a gray substance, more like coagulated albumen than gluten; 59 of starch; 24 of moisture (inclusive of the loss). Schrader found in the ashes of oats, silica, carbonate of lime, carbonate of magnesia, alumina, with oxides of manganese and iron.

OBSIDIAN, is a glassy looking mineral, with a large conchoidal fracture, and of a blackish colour, which froths much at the blow-pipe before it melts into a white enamel.

OCHRE, *yellow and brown* (*Ocre*, Fr.; *Ocker*, Germ.); is a native earthy mixture of silica and alumina, coloured by oxide of iron, with occasionally a little calcareous matter and magnesia. Ochre occurs in beds some feet thick, which lie generally above the oolite, are covered by sandstone and quartzose sands more or less ferruginous, and are accompanied by gray plastic clays, of a yellowish or reddish colour; all of them substances which contribute more or less to its formation. The ochre earths are prepared for use by grinding under edge millstones, and elutriation. The yellow ochres may be easily rendered red or reddish brown by calcination in a reverberatory oven, which oxidizes their iron to a higher degree.

Native red ochre is called red chalk and redde in England. It is an intimate mixture of clay and red iron ochre; is massive; of an earthy fracture; is brownish-red, blood-red, stains and writes red. The oxide of iron is sometimes so considerable, that the ochre may be reckoned an ore of that metal.

The ochre beds of England are in the iron sand, the lowest of the formations which intervene between the chalk and oolites. Beds of fullers' earth alternate with the iron sand. The following is a section of the ochre pits at Shotover Hill, near Oxford:—

| | | |
|---|---|-------------|
| Beds of highly ferruginous grit, forming the summit of the hill | - | 6 feet. |
| Gray sand | - | 3 do. |
| Ferruginous concretions | - | 1 |
| Yellow sand | - | 6 |
| Cream-coloured loam | - | 4 |
| Ochre | - | 0 6 inches. |

Beneath this, there is a second bed of ochre, separated by a thin bed of clay.

Bole, or Armenian bole; called also Lemnian earth, and terra sigillata, because when refined it was stamped with a seal; is massive, with a conchoidal fracture, a feeble lustre, reddish-yellow or brown, a greasy feel; adheres to the tongue, spec. grav. 1·4 to 2·0. It occurs in the island Stalimene (the ancient Lesbos), and in several other places, especially at Sienna; whence the brown pigment called *terra di Sienna*.

OILS (*Huiles*, Fr.; *Oele*, Germ.); are divisible into two great classes: the fat or fixed oils, *huiles grasses*, Fr.; *Fette oele*, Germ.; and the essential or volatile oils, *Huiles volatiles*, Fr.; *Flüchtige, aetherische oele*, Germ. The former are usually bland and mild

to the taste; the latter hot and pungent. The term distilled, applied also to the last class, is not so correct, since some of them are obtained by expression, as the whole of the first class may be, and commonly are.

All the known fatty substances found in organic bodies, without reference to their vegetable or animal origin, are, according to their consistence, arranged under the chemical heads of oils, butters, and tallows. They all possess the same ultimate constituents, carbon, hydrogen, and generally oxygen, and in nearly the same proportions.

The following is a list of the Plants which yield the ordinary Unctuous Oils of commerce:

| No. | Plants. | Oils. | Specific gravity. |
|-----|--|---------------------------------------|-------------------|
| 1. | <i>Linum usitatissimum</i> et perenne D. | Linseed oil - - - | 0.9347 |
| 2. | <i>Corylus avellana</i> } - - D. | Nut oil - - - | 0.9260 |
| 3. | <i>Juglans regia</i> } | | |
| 4. | <i>Papaver somniferum</i> - - D. | Poppy oil - - - | 0.9243 |
| 5. | <i>Cannabis sativa</i> - - - D. | Hemp oil - - - | 0.9276 |
| 6. | <i>Sesamum orientale</i> - - G. | Oil of sesamum - - - | |
| 7. | <i>Olea Europea</i> - - - G. | Olive oil - - - | 0.9176 |
| 8. | <i>Amygdalus communis</i> - - G. | Almond oil - - - | 0.9180 |
| 9. | <i>Guilandina mohringa</i> - - G. | Oil of behen or ben - - - | |
| 10. | <i>Cucurbita pepo</i> , and <i>melapepo</i> D. | Cucumber oil - - - | 0.9231 |
| 11. | <i>Fagus silvatica</i> - - - G. | Beech oil - - - | 0.9225 |
| 12. | <i>Sinapis nigra</i> et <i>arvensis</i> - G. | Oil of mustard - - - | 0.9160 |
| 13. | <i>Helianthus annuus</i> et <i>perennis</i> D. | Oil of sunflower - - - | 0.9262 |
| 14. | <i>Brassica napus</i> et <i>campestris</i> - G. | Rape seed oil - - - | 0.9136 |
| 15. | <i>Ricinus communis</i> - - - D. | Castor oil - - - | 0.9611 |
| 16. | <i>Nicotiana tabacum</i> et <i>rustica</i> - D. | Tobacco seed oil - - - | 0.9232 |
| 17. | <i>Prunus domestica</i> - - - G. | Plum kernel oil - - - | 0.9127 |
| 18. | <i>Vitis vinifera</i> - - - D. | Grape seed oil - - - | 0.9202 |
| 19. | <i>Theobroma cacao</i> - - - G. | Butter of cacao - - - | 0.892 |
| 20. | <i>Cocos nucifera</i> - - - G. | Cocoa nut oil - - - | |
| 21. | <i>Cocus butyracea</i> vel <i>avouira elais</i> G. | Palm oil - - - | 0.968 |
| 22. | <i>Laurus nobilis</i> - - - G. | Laurel oil - - - | |
| 23. | <i>Arachis hypogæa</i> - - - G. | Ground-nut oil - - - | |
| 24. | <i>Vateria indica</i> - - - G. | Piney tallow - - - | 0.926 |
| 25. | <i>Hesperis matronalis</i> - - - D. | Oil of Julienne - - - | 0.9281 |
| 26. | <i>Myagrum sativa</i> - - - D. | Oil of camelina - - - | 0.9252 |
| 27. | <i>Reseda luteola</i> - - - D. | Oil of weld-seed - - - | 0.9358 |
| 28. | <i>Lepidium sativum</i> - - - D. | Oil of garden cresses - - - | 0.9240 |
| 29. | <i>Atropa belladonna</i> - - - D. | Oil of deadly nightshade - - - | 0.9250 |
| 30. | <i>Gossypium Barbadense</i> - - - D. | Cotton seed oil - - - | |
| 31. | <i>Brassica campestris oleifera</i> - - G. | Colza oil - - - | 0.9136 |
| 32. | <i>Brassica præcox</i> - - - G. | Summer rapeseed oil - - - | 0.9139 |
| 33. | <i>Raphanus sativus oleifer</i> - - G. | Oil of radish seed - - - | 0.9187 |
| 34. | <i>Prunus cerasus</i> - - - G. | Cherry-stone oil - - - | 0.9239 |
| 35. | <i>Pyrus malus</i> - - - G. | Apple seed oil - - - | |
| 36. | <i>Euonymus Europæus</i> - - - G. | Spindle tree oil - - - | 0.9380 |
| 37. | <i>Cornus sanguinea</i> - - - G. | Cornil berry tree oil - - - | |
| 38. | <i>Cyperus esculenta</i> - - - G. | Oil of the roots of cyper grass - - - | 0.9180 |
| 39. | <i>Hyoscyamus niger</i> - - - G. | Henbane seed oil - - - | 0.9130 |
| 40. | <i>Æsculus hippocastanum</i> - - G. | Horse chesnut oil - - - | 0.927 |
| 41. | <i>Pinus abies</i> - - - D. | Pinetop oil - - - | 0.9285 |

The fat oils are widely distributed through the organs of vegetable and animal nature. They are found in the seeds of many plants, associated with mucilage, especially in those of the bicotyledonous class, occasionally in the fleshy pulp surrounding some seeds, as the olive; also in the kernels of many fruits, as of the nut and almond tree, and finally in the roots, barks and other parts of plants. In animal bodies, the oily matter occurs enclosed in thin membranous cells, between the skin and the flesh, between the muscular fibres, within the abdominal cavity in the omentum, upon the intestines, and round the kidneys, and in a bony receptacle of the skull of the spermaceti whale; sometimes in

special organs, as of the beaver; in the gall-bladder, &c., or mixed in a liquid state with other animal matters, as in the milk.

Braconnot, but particularly Raspail, have shown that animal fats consist of small microscopic, partly polygonal, and partly reniform particles, associated by means of their containing sacs. These may be separated from each other by tearing the recent fat asunder, rinsing it with water, and passing it through a sieve. The membranes being thus retained, the granular particles are observed to float in the water, and afterwards to separate, like the globules of starch, in a white pulverulent semi-crystalline form. The particles consist of a strong membranous skin, enclosing *stearine and elaine*, or solid and liquid fat, which may be extracted by trituration and pressure. These are lighter than water, but sink readily in spirit of wine. When boiled in strong alcohol, the oily principle dissolves, but the fatty membrane remains. These granules have different sizes and shapes in different animals; in the calf, the ox, the sheep, they are polygonal, and from $\frac{1}{70}$ to $\frac{1}{135}$ of an inch in diameter; in the hog they are kidney-shaped, and from $\frac{1}{70}$ to $\frac{1}{115}$ of an inch; in man, they are polygonal, and from $\frac{1}{70}$ to $\frac{1}{250}$ of an inch; in insects they are usually spherical, and not more than $\frac{1}{250}$ of an inch.

The fat oils are contained in that part of the seed which gives birth to the cotyledons; they are not found in the plumula and radicle. Of all the families of plants, the cruciform is the richest in oleiferous seeds; and next to that, are the drupaceæ, amentaceæ and solanæ. The seeds of the graminææ and leguminosæ contain rarely more than a trace of fat oil. One root alone, that of the *cyperus esculenta*, contains a fat oil. The quantity of oil furnished by seeds varies not only with the species, but in the same seed, with culture and climate. Nuts contain about half their weight of oil; the seeds of the *brassica oleracea* and *campestris*, one third; the variety called *colza* in France, two fifths; hempseed, one fourth; and linseed from one fourth to one fifth. Unverdorben states that a last, or ten quarters, of linseed, yields 40 ahms = 120 gallons English of oil; which is about 1 cwt. of oil per quarter.

The fat oils, when first expressed without much heat, taste merely unctuous on the tongue, and exhale the odour of their respective plants. They appear quite neutral by litmus paper. Their fluidity is very various, some being solid at ordinary temperatures and others remaining fluid at the freezing point of water. Linseed oil indeed does not congeal till cooled from 4° to 18° below 0° F. The same kind of seed usually affords oils of different degrees of fusibility; so that in the progress of refrigeration one portion concretes before another. Chevreul, who was the first to observe this fact, considers all the oils to be composed of two species, one of which resembles *suet*, and was thence styled by him *stearine*; and another which is liquid at ordinary temperatures, and was called *elaine*, or *oleins*. By refrigeration and pressure between the folds of blotting paper or in linen bags, the fluid part is separated, and the solid remains. By heating the paper in water, the liquid oil may be obtained separate. When alcohol is boiled with the natural oil, the greater part of the *stearine* remains undissolved.

Oleine may also be procured by digesting the oil with a quantity of caustic soda equal to one half of what is requisite to saponify the whole; the *stearine* is first transformed into soap, then a portion of the oleine undergoes the same change, but a great part of it remains in a pure state. This process succeeds only with recently expressed or very fresh oils. The properties of these two principles of the fat oils vary with the nature of the respective oils, so that the sole difference does not consist, as many suppose, in the different proportions of these two bodies, but also in peculiarities of the several *stearines* and *oleines*, which, as extracted from different seeds, solidify at very different temperatures.

In close vessels, oils may be preserved fresh for a very long time, but with contact of air they undergo progressive changes. Certain oils thicken and eventually dry into a transparent, yellowish, flexible substance; which forms a skin upon the surface of the oil, and retards its further alteration. Such oils are said to be *drying* or *siccative*, and are used on this account in the preparation of varnishes and painters' colours. Other oils do not grow dry, though they turn thick, become less combustible, and assume an offensive smell. They are then called *rancid*. In this state, they exhibit an acid reaction, and irritate the fauces when swallowed, in consequence of the presence of a peculiar acid, which may be removed in a great measure by boiling the oil along with water and a little common magnesia for a quarter of an hour, or till it has lost the property of reddening litmus. While oils undergo the above changes, they absorb a quantity of oxygen equal to several times their volume. Saussure found that a layer of nut oil, one quarter of an inch thick, enclosed along with oxygen gas over the surface of quicksilver in the shade, absorbed only three times its bulk of that gas in the course of eight months; but when exposed to the sun in August, it absorbed 60 volumes additional in the course of ten days. This absorption of oxygen diminished progressively, and stopped altogether at the end of three months, when it had amounted to 145 times the bulk of the oil. No water was generated, but 21.9 volumes of carbonic acid were dis-

engaged, while the oil was transformed in an anomalous manner into a gelatinous mass, which did not stain paper. To a like absorption we may ascribe the elevation of temperature which happens when wool or hemp, besmeared with olive or rapeseed oil, is left in a heap; circumstances under which it has frequently taken fire, and caused the destruction of both cloth-mills and dock-yards.

In illustration of these accidents, if paper, linen, tow, wool, cotton, mats, straw, wood shavings, moss, or soot, be imbued slightly with linseed or hempseed oil, and placed in contact with the sun and air, especially when wrapped or piled in a heap, they very soon become spontaneously hot, emit smoke, and finally burst into flames. If linseed oil and ground manganese be triturated together, the soft lump so formed will speedily become firm, and ere long take fire.

The fat oils are completely insoluble in water. When agitated with it, the mixture becomes turbid, but if it be allowed to settle the oil collects by itself upon the surface. This method of washing is often employed to purify oils. Oils are little soluble in alcohol, except at high temperatures. Castor oil is the only one which dissolves in cold alcohol. Ether, however, is an excellent solvent of oils, and is therefore employed to extract them from other bodies in analysis; after which it is withdrawn by distillation.

Fat oils may be exposed to a considerably high temperature, without undergoing much alteration; but when they are raised to nearly their boiling point, they begin to be decomposed. The vapours that then rise are not the oil itself, but certain products generated in it by the heat. These changes begin somewhere under 600° of Fahr., and require for their continuance temperatures always increasing. The products consist at first in aqueous vapour, then a very inflammable volatile oil, which causes boiling oil to take fire spontaneously; and next carburetted hydrogen gas, with carbonic acid gas. In a lamp, a small portion of oil is raised in the wick by capillarity, which being heated, boils and burns. See ROSIN-GAS.

Several fat oils, mixed with one or two per cent. of sulphuric acid, assume instantly a dark green or brown hue, and, when allowed to stand quietly, deposit a colouring matter after some time. It consists in a chemical combination of the sulphuric acid with a body thus separated from the oil, which becomes in consequence more limpid, and burns with a brighter flame, especially after it is washed with steam, and clarified by repose or filtration. Any remaining moisture may be expelled by the heat of a water bath.

The oils combine with the salifiable bases, and give birth to the substance called *glycerine* (the sweet principle), and to the margaric, oleic, and stearic acids. The general product of their combination with potash or soda, is SOAP, which see. Caustic ammonia changes the oils very difficultly and slowly into a soap; but it readily unites with them into a milky emulsion called volatile liniment, used as a rubefacient in medicine. Upon mixing water with this liquor, the oil separates in an unchanged state. By longer contact, ammonia acts upon oils like the other alkalis. Sea salt dissolves in small quantity in the oils, and so does verdigris. The latter solution is green. Oils dissolve also several of the vegetable alkalis, as morphia, cinchonia, quinia, strychnia, and delphia.

Olive oil consists of 77·2 carbon, 13·4 hydrogen, and 9·4 oxygen, in 100 parts. Spermaceti oil, by my analysis, of 78·9 carbon, 10·97 hydrogen, and 10·13 oxygen.

| | | | | | |
|-----------------------|-----|----------|-------|-------|-----------------------|
| Castor oil | do. | - - 74·0 | 10·3 | 15·7 | azote, |
| Stearine of olive oil | - - | 82·17 | 11·23 | 6·30 | 0·30 <i>Saussure.</i> |
| Oleine of do. | - - | 76·03 | 1·154 | 13·07 | 0·35 do. |
| Linseed oil | - - | 76·01 | 11·35 | 12·64 | do. |
| Nut oil | - - | 79·77 | 10·57 | 9·12 | 0·54 do. |
| Oil of almonds | - - | 77·40 | 11·48 | 10·83 | 0·29 |

De Saussure concludes that the less fusible fats contain more carbon and less oxygen, and that oils are more soluble in alcohol, the more oxygen they contain.

I shall now take a short view of the peculiarities of the principal expressed oils.

Oil of almonds, according to Gusserson, contains no stearine; at least he could obtain none by cooling it and squeezing it successively till it all congealed. Braconnot had, on the contrary, said, that it contains 24 per cent. of stearine. I believe that Gusserson is right, and that Braconnot had made fallacious experiments on an impure oil.

Oil of colza, is obtained from the seeds of *brassica campestris*, to the amount of 39 per cent. of their weight. It forms an excellent lamp oil, and is much employed in France.

The *corylus avellana* furnishes in oil 60 per cent. of the weight of the nuts.

Hempseed oil, resembles the preceding, but has a disagreeable smell, and a mawkish taste. It is used extensively for making both soft soap and varnishes.

Linseed oil, is obtained in greatest purity by cold pressure; but by a steam heat of about 200° F. a very good oil may be procured in larger quantity. The proportion of

oil usually stated by authors is 22 per cent. of the weight of the seed; but Mr. Blundell informs me, that, by his plan of hydraulic pressure, he obtains from 26 to 27. In the *Encyclopædia Metropolitana*, under *Oil Press*, a quarter of seed (whose average weight is 400 lbs.) is said to yield 20 gallons of oil. Now as the gallon of linseed oil weighs 9.3 lbs., the total product will be 186 lbs., which amounts to more than 45 per cent. — an extravagant statement, about double the ordinary product in oil mills. Even supposing the gallons not to be imperial, but old English, we should have upwards of 38 per cent. of oil by weight, which is still an impossible quantity. Such are the errors introduced into respectable books, by adopting without practical knowledge the puffing statements of a patentee. It dissolves in 5 parts of boiling alcohol, in 40 parts of cold alcohol, and in 1.6 parts of ether. When kept long cool in a cask partly open, it deposits masses of white stearine along with a brownish powder. That stearine is very difficult of saponification.

Mustard seed oil. The white or yellow seed affords 36 per cent. of oil, and the black seed 18 per cent. The oil concretes when cooled a little below 32° F.

Nut oil, is at first greenish coloured, but becomes pale yellow by time. It congeals at the same low temperature as linseed oil, into a white mass, and has a more drying quality than it.

Oil of olives, is sometimes of a greenish and at others of a pale yellow colour. A few degrees above 32° F. it begins to deposit some white granules of stearine, especially if the oil have been originally expressed with heat. At 23° it deposits 28 per cent. of its weight in stearine, which is fusible again at 68°, and affords 72 per cent. of oleine. According to Kerwych, oleine of singular beauty may be obtained by mixing 2 parts of olive oil with 1 part of caustic soda lye, and macerating the mixture for 24 hours with frequent agitation. Weak alcohol must then be poured into it, to dissolve the stearine soap, whereby the oleine, which remains meanwhile unsaponified, is separated, and floats on the surface of the liquid. This being drawn off, a fresh quantity of spirits is to be poured in, till the separation of all the oleine be completed. It has a slightly yellowish tint, which may be removed by means of a little animal charcoal mixed with it in a warm place for 24 hours. By subsequent filtration, the oleine is obtained limpid and colourless, of such quality that it does not thicken with the greatest cold, nor does it affect either iron or copper instruments immersed in it.

There are three kinds of olive oil in the market. The best, called virgin salad oil, is obtained by a gentle pressure in the cold; the more common sort is procured by stronger pressure, aided with the heat of boiling water; and thirdly, an inferior kind, by boiling the olive residuum or *marc*, with water, whereby a good deal of mucilaginous oil rises and floats on the surface. The latter serves chiefly for making soaps. A still worse oil is got by allowing the mass of bruised olives to ferment before subjecting it to pressure.

Oil of olives is refined for the watchmakers by the following simple process. Into a bottle or phial containing it, a slip of sheet lead is immersed, and the bottle is placed at a window, where it may receive the rays of the sun. The oil by degrees gets covered with a curdy mass, which after some time settles to the bottom, while itself becomes limpid and colourless. As soon as the lead ceases to separate any more of that white substance, the oil is decanted off into another phial for use.

There are four different kinds of olive oil known in the districts where it is prepared: 1. the virgin oil; 2. the ordinary oil (*huile ordinaire*); 3. oil of the infernal regions (*huile d'enfer*); 4. oil prepared by fermentation.

1. *Virgin oil.* In the district Montpellier, they apply the term *virgin* oil to that which spontaneously separates from the paste of crushed olives. This oil is not met with in commerce, being all used by the inhabitants of the district, either as an emollient remedy, or for oiling the works of watches.

In the district of Aix, they give the name *virgin oil* to that which is first obtained from the olives ground to a paste in a mill, and submitted to a slight pressure 2 or 3 days after collecting the fruit. Thus, there is no virgin oil brought from Montpellier, but a good deal of it is brought from Aix.

2. *Ordinary oil.* In the district of Montpellier, this oil is prepared by pressing the olives, previously crushed and mixed with boiling water. At Aix, the *ordinary oil* is made from the olives which have been used for obtaining the *virgin oil*. The paste, which has been previously pressed, is broken up, a certain quantity of boiling water is poured over it, and it is then again submitted to the press. By this second expression, in which more pressure is applied than in the previous one, an oil is obtained somewhat inferior in quality to the *virgin oil*. The oil is separated from the water in a few hours after the operation.

3. *Oil of the infernal regions (huile d'enfer).* The water which has been employed in the preceding operation, is, in some districts, conducted into large reservoirs, called the infernal regions, where it is left for many days. During this period, any oil that might

have remained mixed with the water separates, and collects on the surface. This oil being very inferior in quality, is only fit for burning in lamps, for which it answers very well. It is sometimes called *lamp oil*.

4. *Fermented oil (huile fermentée)*. This is obtained in the two above-named districts, by leaving the fresh olives in heaps for some time, and pouring boiling water over them before pressing the oil. But this method is very seldom put in practice, for the olives during this fermentation lose their peculiar flavour, become much heated, and acquire a musty taste, which is communicated to the oil.

The fruity flavour of the oil depends upon the quality of the olives from which it has been pressed, and not upon the method adopted in its preparation.

There are met with in commerce the virgin oil of Aix, rarely the oil obtained by fermentation, and never the oil of the infernal regions.

Palm oil melts at 117.5° F., and is said to consist of 31 parts of stearine and 69 of oleine in 100. It becomes readily rancid by exposure to air, and is whitened at the same time.

The oil extracted from the plucked tops of the *pinus abies*, in the Black Forest in Germany, is limpid, of a golden yellow colour, and resembles in smell and taste the oil of turpentine. It answers well for the preparation of varnishes.

The oil of *plum-stones*, is made chiefly in Wurtemberg, and is found to answer very well for lamps.

Poppy-seed oil, has none of the narcotic properties of the poppy juice. It is soluble in ether in every proportion.

Rape-seed oil, has a yellow colour, and a peculiar smell. At 25° F. it becomes a yellow mass, consisting of 46 parts of stearine, which fuses at 50°, and 54 of oleine, in which the small resides.

The oils of *belladonna seeds* and *tobacco seeds* are perfectly bland. The former is much used for lamps in Swabia and Wurtemberg. The oil-cakes of both are poisonous.

Oil of wine-stones, is extracted to the amount of 10 or 11 per cent. from the seeds of the grape. Its colour is at first pale yellow, but it darkens with age. It is used as an article of diet.

FAT OIL MANUFACTURE.

It is the practice of almost all the proprietors in the neighbourhood of Aix, in Provence, to preserve the olives for 15 days in barns or cellars, till they have undergone a species of fermentation, in order to facilitate the extraction of their oil. If this practice were really prejudicial to the product, as some theorists have said, would not the high reputation and price of the oil of Aix have long ago suffered, and have induced them to change their system of working? In fact all depends upon the degree of fermentation excited. They must not be allowed to mould in damp places, to lie in heaps, to soften so as to stick to each other, and discharge a reddish liquor, or to become so hot as to raise a thermometer plunged into the mass up to 96° F. In such a case they would afford an acrid nauseous oil, fit only for the woollen or soap manufactories. A slight fermentative action, however, is useful, towards separating the oil from the mucilage. The olives are then crushed under the stones of an edge-mill, and next put into a screw-press, being enclosed in bullrush-mat bags (*cabas*), laid over each other to the number of eighteen. The oil is run off from the channels of the ground-sill into casks, or into stone cisterns called *pizes*, two-thirds filled with water. The pressure applied to the *cabas* should be slowly graduated.

What comes over first, without heat, is the virgin oil already mentioned. The *cabas* being now removed from the press, their contents are shovelled out, mixed with some boiling water, again put in the bags, and pressed anew. The hot water helps to carry off the oil, which is received in other casks or *pizes*. The oil ere long accumulates at the surface, and is skimmed off with large flat ladles; a process which is called *lever l'huile*. When used fresh, this is a very good article, and quite fit for table use, but is apt to get rancid when kept. The subjacent water retains a good deal of oil, by the intervention of the mucilage; but by long repose in a large general cistern, called *l'enfer*, it parts with it, and is then drawn off from the bottom by a plug-hole. The oil which remains after the water is run off, is of an inferior quality, and can be used only for factory purposes.

The marc being crushed in a mill, boiled with water, and expressed, yields a still coarser article.

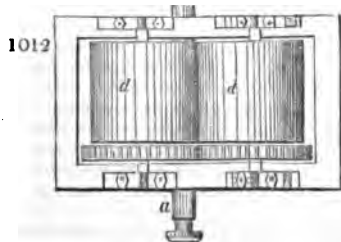
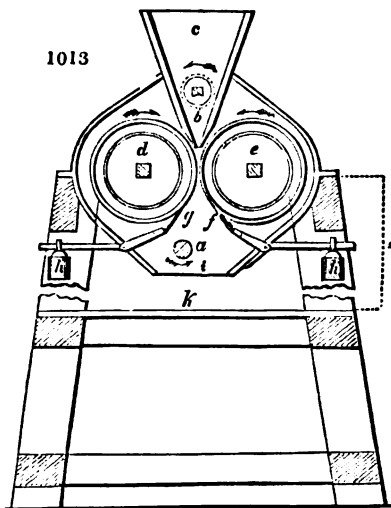
All the oil must be *fined* by keeping in clean tuns, in an apartment, heated to the 60th degree Fahr. at least, for twenty days; after which it is run off into strong casks, which are cooled in a cellar, and then sent into the market.

Oil of almonds, is manufactured by agitating the kernels in bags, so as to separate their brown skins, grinding them in a mill, then enclosing them in bags, and squeezing

them strongly between a series of cast-iron plates, in a hydraulic press; without heat at first, and then between heated plates. The first oil is the purest, and least apt to become rancid. It should be refined by filtering through porous paper. Next to olive oil, this species is the most easy to saponify. Bitter almonds being cheaper than the sweet, are used in preference for obtaining this oil, and they afford an article equally bland, wholesome, and inodorous. But a strongly scented oil may be procured, according to M. Planché, by macerating the almonds in hot water, so as to blanch them, then drying them in a stove, and afterwards subjecting them to pressure. The volatile oil of almonds is obtained by distilling the marc or bitter almond cake along with water. See PRESS HYDRAULIC, and STEARINE.

Linseed, rapeseed, poppyseed, and other oleiferous seeds were formerly treated for the extraction of their oil, by pounding in hard wooden mortars with pestles shod with iron, set in motion by cams driven by a shaft turned with horse or water power, then the triturated seed was put into woollen bags which were wrapped up in hair-cloths, and squeezed between upright wedges in press-boxes by the impulsion of vertical rams driven also by a cam mechanism. In the best mills upon the old construction, the cakes obtained by this first wedge pressure, were thrown upon the bed of an edge-mill, ground anew, and subjected to a second pressure, aided by heat now, as in the first case. These mortars and press-boxes constitute what are called Dutch mills. They are still in very general use both in this country and on the Continent; and are by many persons supposed to be preferable to the hydraulic presses.

The roller-mill for merely bruising the linseed, &c, previous to grinding it under edge-stones, and to heating and crushing it in a Dutch or a hydraulic oil-mill, is represented in *figs.* 1012. and 1013. The iron shaft



figs. 1012. and 1013. The iron shaft *a*, has a winch at each end, with a heavy fly-wheel upon the one of them, when the machine is to be worked by hand. Upon the opposite end is a pulley, with an endless cord which passes round a pulley on the end of the fluted roller *b*, and thereby drives it. This fluted roller *b*, lies across the hopper *c*, and by its agitation causes the seeds to descend equably through the hopper, between the crushing rollers *d*, *e*. Upon the shaft *a*, there is also a pinion which works into two toothed wheels on the shafts of the crushing cylinders *d* and *e*, thus communicating to these cylinders motion in opposite directions. *f*, *g*, are two scraper-blades, which by means of the two weights *h*, *h*, hanging upon levers, are pressed against the surfaces of the cylinders, and remove any seed-cake from them. The bruised seeds fall through the slit *i* of the case, and are received into a chest which stands upon the board *k*.

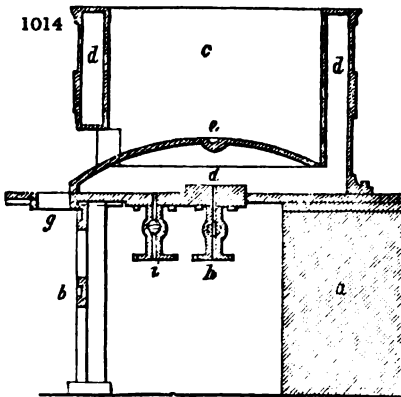
Machines of this kind are now usually driven by power. Hydraulic presses have been of late years introduced into many seed-oil mills in this country; but it is still a matter of dispute whether they or the old Dutch oil-mill, with bags of seed compressed between wedges, driven by cam-stamps, be the preferable; that is, afford the largest product of oil with the same expenditure of capital and power. For figures of hydraulic presses, see PRESS, and STEARINE.

This bruising of the seed is merely a preparation for its proper grinding under a pair of heavy edge-stones, of granite, from 5 to 7 feet in diameter; because unbruised seed is apt to slide away before the vertical rolling wheel, and thus escape trituration. The edge-mill, for grinding seeds, is quite analogous to the gunpowder-mill represented in *fig.* 740, page 980. Some hoop the stones with an iron rim, but others prefer, and I think justly, the rough surface of granite, and dress it from time to time with hammers, as it becomes irregular. These stones make from 30 to 36 revolutions upon their

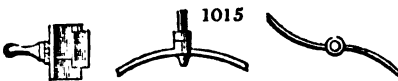
horizontal bed of masonry or iron in a minute. The centre of the bed, where it is perforated for the passage of the strong vertical shaft which turns the stones, is enclosed by a circular box of cast-iron, firmly bolted to the bed-stone, and furnished with a cover. This box serves to prevent any seeds or powder getting into the step or socket, and obstructing the movement. The circumference of the mill-bed is formed of an upright rim of oak-plank, bound with iron. There is a rectangular notch left in the edge of the bed, and corresponding part of the rim, which is usually closed with a slide-plate, and is opened only at the end of the operation, to let the pasty seed-cake be turned out by the oblique arm of the bottom scraper. The two parallel stones, which are set near each other, and travel round their circular path upon the bed, grind the seeds not merely by their weight, of three tons each, but also by a rubbing motion, or attrition; because their periphery being not conical, but cylindrical, by its rolling upon a plane surface, must at every instant turn round with friction upon their resting points. Strong cast-iron boxes are bolted upon the centre of the stones, which by means of screw clamps seize firmly the horizontal iron shafts that traverse and drive them, by passing into a slit-groove the vertical turning shaft. This groove is lined with strong plates of steel, which wear rapidly by the friction, and need to be frequently renewed.

The seeds which have been burst between the rolls, or in the mortars of the Dutch mills, are to be spread as equally as possible by a shovel upon the circular path of the edge-stones, and in about half an hour the charge will be sufficiently ground into a paste. This should be put directly into the press, when fine cold-drawn oil is wanted. But in general the paste is heated before being subjected to the pressure. The pressed cake is again thrown under the edge stones, and, after being ground the second time, should be exposed to a heat of 212° Fahr., in a proper pan, called a steam-kettle, before being subjected to the second and final pressure in the woollen bags and hair-cloths.

Fig. 1014 is a vertical section of the steam-kettle of Hallette, and *fig. 1015* is a view of



the seed-stirrer. *a*, is the wall of masonry, upon which, and the iron pillar, *b*, the pan is supported. It is enclosed in a jacket, for admitting steam into the intermediate space *d, d, d*, at its sides and bottom; *c*, is the middle of the pan in which the shaft of the stirrer is planted upright, resting by its lower end in the step *e*; *f*, is an opening, by which the contents of the pan may be emptied; *g*, is an orifice into which the mouth of the hair or worsted bag is inserted, in order to receive the heated seed, when it is turned out by the rotation of the stirrer and the withdrawal of the plug *f* from the discharge aperture; *h*, is the steam induction pipe; and *k*, the eduction pipe which serves also to run off the condensed water.



The hydraulic oil-press is generally double; that is, it has two vertical rams placed parallel to each other, so that while one side is under pressure, the

other side is being discharged. The bags of heated seed-paste or meal are put into cast-iron cases, which are piled over each other to the number of 6 or 8, upon the press sill, and subjected to a force of 300 or 400 tons, by pumps worked with a steam engine. The first pump has usually 2 or $2\frac{1}{2}$ inches diameter for a ram of 10 inches, and the second pump one inch. Each side of the press, in a well-going establishment, should work 38 pounds of seed-flour every 5 minutes. Such a press will do 70 quarters of linseed in the day's work of one week, with the labour of one man at 20s. and three boys at 5s. each; and will require a 12-horse power to work it well, along with the rolls and the edge-stones.

I am indebted to my excellent friend Mr. E. Woolsey, for the following most valuable notes, taken by him at sundry mills for pressing oil; and remarks upon the subject of seed-crushing in general.

"The chief point of difference depends upon the quality of seed employed. Heavy seed will yield most oil, and seed ripened under a hot sun, and where the flax is not gathered too green, is the best. The weight of linseed varies from 48 to 52 lbs. per imperial bushel; probably a very fair average is 49 lbs., or 392 lbs. per imperial quarter. I inspected one of the seed-crusher's books, and the average of 15 trials of

a quarter each of different seeds in the season averaged $14\frac{1}{2}$ galls. of $7\frac{1}{2}$ lbs. each; say, 109 lbs. of oil per quarter. This crusher, who uses only the hydraulic press, and one pressing, informed me that

Archangel seed will yield from - - - - 15 to 16 gals. (of $7\frac{1}{2}$ lbs. each)
 Best Odessa - - - - - 18 and even 19 gals.
 Good crushing-seed - - - - - $15\frac{1}{2}$ do.
 Low seed, such as weighs 48 lbs. per bushel - $13\frac{1}{2}$ do.

"The average of the seed he has worked, which he represents to be of an inferior quality, for the sake of its cheapness, yields $14\frac{1}{2}$ galls. per quarter. I had some American seed which weighed $52\frac{1}{2}$ lbs. per imperial bushel, ground and pressed under my own observation, and it gave me 111 lbs. oil; that is to say, 418 lbs. of seed gave 111 lbs. oil = $26\frac{3}{100}$ per cent. A friend of mine, who is a London crusher, told me the oil varied according to the seed from 14 to 17 galls.; and when you consider the relative value of seeds, and remember that *oil* and *cake* from any kind of seed is of the same value, it will be apparent that the yield is very different; for example,

25th July, 1836, { E. India linseed worth 52s. per quarter.
 prices of seed. { Petersburg linseed 48 to 52 do.
 Odessa - - - 52 - - -

The difference of 4s. must be paid for in the quantity of oil, which at 38s. 6d. per. cwt. (the then price) requires about $11\frac{1}{2}$ lbs. more oil expressed to pay for the difference in the market value of the seed. Another London crusher informed me that East India linseed will produce 17 gallons, and he seemed to think that that was the extreme quantity that could be expressed from any seed. The average of last year's Russian seed would be about 14 galls.; Sicilian seed 16 galls.

| Place. | Engine Power. | Hydraulic Presses. | Stampers. | Rollers. | Edge-stones. | Kettles. | Work done,—reduced to an hour. | Number of pressings. |
|--------|---|------------------------|------------------------|---|--|---|--------------------------------------|----------------------|
| France | 10 horse power | 1 hydraulic, 300 tons. | 5 light stampers. | 1 pair rolls. | 1 pr. edge-stones. | 5 table kettles small size heated by steam. | 1 English quarter per working hour. | 2 pressings. |
| London | 20 horse power | 1 hydraulic, 800 tons. | 13 light stampers. | 1 pair rolls. | 3 pr. edge-stones. | 8 table kettles small size heated by fire. | 2 English quarters working hour. | 2 ditto |
| London | 12 horse power, but the engine is used also for other work. | none | 9 light stampers. | 2 pair rolls, used also for other purposes. | 2 pr. edge-stones, used also for other purposes. | 4 table kettles small size heated by fire. | 1 English quarter per working hour. | 2 ditto |
| Hull | 18 horse engine, old construction. | none | 3 very heavy stampers. | 1 pair rolls. | 1 pr. edge-stones. | 3 double case large size steam kettles. | 1½ English quarter per working hour. | 1 ditto |
| Ditto | 22 horse engine | none | 6 very heavy stampers. | 2 pair rolls. | 3 pr. edge-stones. | 6 double case large size steam kettles. | Not known. | 1 ditto |

"Rape-seed.—I have not turned my attention to the quantity of oil extracted from this seed; but a French crusher (M. Geremboret), on whom I think one may place considerable dependence, told me, that

$9\frac{1}{2}$ lbs. of best Cambray rape-seed yielded - - - 1 lb. oil.
 $3\frac{1}{2}$ — common rape-seed - - - - - 1 lb. oil.
 $4\frac{1}{2}$ — poppy-seed - - - - - 1 lb. oil.

"Rape-seed weighs from 52 to 56 lbs. per imperial bushel."

The following are the heads of a reference of machinery for a seed oil-mill:—

1. Two pairs of cast-iron rollers 19 inches long, and 10 inches in diameter, fixed in a cast-iron frame, with brasses, wheels, shafts, bolts, scrapers, hoppers, shoes, &c.
2. Two pairs of edge-stones, 7 feet diameter each, with two bottom stones, 6 feet diameter each, cast-iron upright shafts, sweepers, wheels, shafts, chairs, brasses, bolts, and scrapers, with driving spur-wheels, &c.
3. Five steam kettles, with wheels, shafts, and brasses, bolts, breeches, and steam pipes, an upright cast-iron shaft, with chairs and brasses at each end; and a large level wheel upon the bottom end of upright shaft, and another, smaller, upon fly-wheel shaft, for the first motions.

4. Five stamper presses, with press plates of cast-iron, cast-iron stamper shaft with 10 arms, and 10 rollers, with bosses, brasses, bolts, driving bevel-wheels.

A well-made oil-mill, consisting of the above specified parts, will manufacture 200 quarters of seed per week.

I have been assured by practical engineers, conversant in oil-mills, that a double hydraulic press, with 2 ten-inch rams, will do the work of no more than two of the stamper presses; that is to say, it will work 22 quarters in 24 hours; while three stamper presses will work 33 quarters in the same time, and produce one half more oil.

Oil, Cocoa-nut, imported in 1850, 98,040 cwts., in 1851, 55,994 cwts.

Oil, Olive, imported in 1850, 20,784 tuns, in 1851, 11,488 tuns.

Oil, Train, Blubber, and Spermaceti, imported in 1850, 21,359 tuns, in 1851, 22,219 tuns. For Seal Oil, see SEAL FISHERY.

OILS, VOLATILE OR ESSENTIAL; Manufacture of. The volatile oils occur in every part of odoriferous plants, whose aroma they diffuse by their exhalation; but in different organs of different species. Certain plants, such as thyme and the scented *labiate* in general, contain volatile oil in all their parts; but others contain it only in the blossoms, the seeds, the leaves, the root, or the bark. It sometimes happens that different parts of the same plant contain different oils; the orange, for example, furnishes three different oils, one of which resides in the flowers, another in the leaves, and a third in the skin or epidermis of the fruit. The quantity of oil varies not only with the species, but also in the same plant with the soil, and especially the climate; thus in hot countries it is generated most profusely. In several plants, the volatile oil is contained in peculiar orders of vessels, which confine it so closely that it does not escape in the drying, nor is dissipated by keeping the plants for many years. In other species, and particularly in flowers, it is formed continually upon their surface, and flies off at the moment of its formation.

Volatile oils are usually obtained by distillation. For this purpose the plant is introduced into a still, water is poured upon it, and heat being applied, the oil is volatilized by the aid of the watery vapour at the temperature of 212°, though when alone it would probably not distil over unless the heat were 100° more. This curious fact was first explained in my *New Researches upon Heat*, published in the Philosophical Transactions for 1818. Most of the essential oils employed in medicine and perfumery are extracted by distillation from dried plants; only a few, such as those of the rose and orange flower, are obtained from fresh or succulent salted plants. When the mingled vapours of the oil and water are condensed into the liquid state, by the refrigerator of the still, the oil separates, and either floats on the surface or sinks to the bottom of the water. Some oils of a less volatile nature require a higher heat than 212° to raise them in vapour, and must be dislodged by adding common salt to the water, whereby the heat being augmented by 15°, they readily come over. If in such distillations too much water be added, no oil will be obtained, because it is partially soluble in water; and thus merely an aromatic water is produced. If on the other hand too little water be used, the plant may happen to adhere to the bottom of the still, get partially charred, and thus impart an empyreumatic odour to the product. But as the quality of water distilled depends less upon the quantity employed, than upon that of the surface exposed to the heat, it is obvious that by giving a suitable form to the still, we may get rid of every inconvenience. Hence the narrower and taller the alembic is, within certain limits, the greater will be the proportion of oil relative to that of the aromatic water, from like proportions of aqueous and vegetable matter employed. Some place the plants in baskets, and suspend these immediately over the bottom of the still under the water, or above its surface in the steam. But the best mode in my opinion is to stuff an upright cylinder full of the plants, and to drive down through them steam of any desired force; its tension and temperature being further regulated by the size of the outlet orifice leading to the condenser. The cylinder should be made of strong copper tinned inside and encased in the worst conducting species of wood, such as soft deal or sycamore.

The distillation is to be continued as long as the water comes over of a milky appearance. Certain plants yield so little oil by the ordinary processes, notwithstanding every care, that nothing but a distilled water is obtained. In this case, the same water must be poured upon a fresh quantity of the plants in the still; which being drawn over is again to be poured upon fresh plants; and thus repeatedly, till a certain dose of oil be separated. This being taken off, the saturated water is reserved for a like distillation.

The refrigeratory vessel is usually a worm or serpentine plunged in a tub of water, whose temperature should be generally cold; but for distilling the oils of anise-seed, fennel, &c., which become concrete at low temperatures, the water should not be cooler than 45° F.

The liquid product is commonly made to run at the worm end, into a vessel called an Italian or Florentine receiver, which is a conical matrass, standing on its base, with a pipe rising out of the side close to the bottom, and recurved a little above the middle

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volume of oxygen, and had disengaged twice its volume of carbonic acid gases; nor was it yet completely saturated with oxygen. The steariness of anise-seed oil absorbed at its liquefying temperature, in the space of two years, 156 times its volume of oxygen gas, and disengaged 26 times its volume of carbonic acid gas. An oil which has begun to experience such an oxidizement is composed of a resin dissolved in the unaltered oil; and the oil may be separated by distilling the solution along with water. To preserve oils in an unchanged state, they must be put in phials, filled to the top, closed with ground glass stopples, and placed in the dark.

Volatile oils are little soluble in water, yet enough so as to impart to it by agitation their characteristic smell and taste. The water which distils with any oil is in general a saturated solution of it, and as such is used in medicine under the name of distilled water. It often contains other volatile substances, contained in the plants, and hence is apt to putrefy and acquire a nauseous smell when kept in perfectly corked bottles; but in vessels partially open, these parts exhale, and the water remains sweet. The waters, however, which are made by agitating volatile oil with simple distilled water are not apt to spoil by keeping in well-corked bottles.

The volatile oils are soluble in alcohol, and the more so the stronger the spirit is. Some volatile oils, devoid of oxygen, such as the oils of turpentine and citron, are very sparingly soluble in dilute alcohol; while the oils of lavender, pepper, &c. are considerably so. De Saussure has inferred from his experiments that the volatile oils are the more soluble in alcohol, the more oxygen they contain. Such combinations form the odiferous spirits which the perfumers incorrectly call waters, as *lavender water, eau de Cologne, eau de jasmin, &c.* They become turbid by admixture of water, which seizes the alcohol, and separates the volatile oils. Ether also dissolves all the essential oils.

These oils combine with several vegetable acids, such as the acetic, the oxalic, the succinic, the fat acids (stearic, margaric, oleic), the camphoric, and suberic.

With the exception of the oil of cloves, the volatile oils do not combine with the salifiable bases. They have been partially combined with caustic alkali, as in the case of Starkey's soap. This is prepared by triturating recently fused caustic soda in a mortar, with a little oil of turpentine, added drop by drop, till the mixture has acquired the consistence of soap. The compound is to be dissolved in spirits of wine, filtered, and distilled. What remains after the spirit is drawn off, consists of soda combined with a resin formed in the oil during the act of trituration.

The volatile oils in general absorb six or eight times their bulk of ammoniacal gas; but that of lavender absorbs 47 times.

The essential oils dissolve all the fat oils, the resins, and the animal fats.

In commerce these oils are often adulterated with fat oils, resins, or balsam of capivi dissolved in volatile oil. This fraud may be detected by putting a drop of the oil on paper and exposing it to heat. A pure essential oil evaporates without leaving any residuum, whilst an oil mixed with any of the above substances leaves a translucent stain upon the paper. If fat oil be present, it will remain undissolved, on mixing the adulterated essential oil with thrice its volume of spirit of wine of specific gravity 0.840. Resinous matter mixed with volatile oil is easily detected, being left in the alembic after distillation. Oil diluted with spirit of wine forms a milky emulsion on the addition of water; the alcoholic part is absorbed by the water, and the oil afterwards found on the surface, in a graduated glass tube, will show by its quantity the amount of the adulteration.

But it is more difficult to detect the presence of a cheap essential oil in a dear one, which it resembles. Here the taste and smell are our principal guides. A few drops of the suspected oil are to be poured upon a bit of cloth, which is to be shaken in the air, and smelled to from time to time. In this way we may succeed in distinguishing the odour of the oil which exhales at the beginning, and that which exhales at the end; a method which serves perfectly to detect oil of turpentine in the finer essential oils. Moreover, when the debased oil is mixed with spirits of wine at sp. gr. 0.840, the oil of turpentine remains in a great measure undissolved. If an oil heavier than water, and an oil lighter than water, be mixed, they may be separated by agitation for some time with that liquid and then leaving the mixture at rest. Essential oils may also be distinguished by a careful examination of their respective densities.

Oil of bitter almonds, is prepared by exposing the bitter almond cake, from which the bland oil has been expressed, in a sieve to the vapour of water rising within the still. The steam, as it passes up through the bruised almond *parenchyma*, carries off its volatile oil, and condenses along with it in the worm. The oil which first comes over, and which falls to the bottom of the water, has so pungent and penetrating a smell, that it is more like cyanogen gas than hydrocyanic or prussic acid. This oil has a golden-yellow colour, it is heavier than water; when much diluted, it has an agreeable smell, and a bitter burning taste. When exposed to the air, it absorbs oxygen, and lets fall a heap of crystals of benzoic acid. This oil consists of a mixture of two oils; one of which is volatile, contains hydrocyanic acid, and is poisonous; the other is less volatile, is not

of the flask like the spout of a coffee-pot. The water and the oil collected in this vessel, soon separate from each other, according to their respective specific gravities; the one floating above the other. If the water be the denser, it occupies the under portion of the vessel, and continually overflows by the spout in communication with the bottom while the lighter oil is left. When the oil is the heavier of the two, the receiver should be a large inverted cone, with a stopcock at its apex to run off the oil from the water when the separation has been completed by repose. A funnel, having a glass stopcock attached to its narrow stem, is the most convenient apparatus for freeing the oil finally from any adhering particles of water. A cotton wick dipped in the oil may also serve the same purpose by its capillary action. The less the oil is transversed the better, as a portion of it is lost at every transfer. It may occasionally be useful to cool the distilled water by surrounding it with ice, because it thus parts with more of the oil with which it is impregnated.

There are a few essential oils which may be obtained by expression, from the substances which contain them; such as the oils of lemons and bergamot, found in the pellicle of the ripe fruits of the *citrus aurantium* and *medica*; or the orange and the citron. The oil comes out in this case with the juice of the peel, and collects upon its surface.

For collecting the oils of odoriferous flowers which have no peculiar organs for imprisoning them, and therefore speedily let them exhale, such as violets, jasmine, tuberose, and hyacinth, another process must be resorted to. Alternate layers are formed of the fresh flowers, and thin cotton fleece or woollen cloth-wadding, previously soaked in a pure and inodorous fat oil. Whenever the flowers have given out all their volatile oil to the fixed oil upon the fibrous matter, they are replaced by fresh flowers in succession, till the fat oil has become saturated with the odorous particles. The cotton or wool wadding being next submitted to distillation along with water gives up the volatile oil. Perfumers alone use these oils; they employ them either mixed as above, or dissolve them out by means of alcohol. In order to extract the oils of certain flowers, as for instance of white lilies, infusion in a fat oil is sufficient.

Essential oils differ much from each other in their physical properties. Most of them are yellow, others are colourless, red, or brown; some again are green, and a few are blue. They have a powerful smell, more or less agreeable, which immediately after their distillation is occasionally a little rank, but becomes less so by keeping. The odour is seldom as pleasant as that of the recent plant. Their taste is acrid, irritating, and heating, or merely aromatic when they are largely diluted with water or other substances. They are not greasy to the touch, like the fat oils, but on the contrary make the skin feel rough. They are almost all lighter than water, only a very few falling to the bottom of this liquid; their specific gravity lies between 0.847 and 1.096; the first number denoting the density of oil of citron, and the second that of oil of sassafras. Although styled volatile oils, the tension of their vapour, as well as its specific heat, is much less than that of water. The boiling point differs in different kinds, but it is usually about 316° or 320° Fahr. Their vapours sometimes render reddened litmus paper blue, although they contain no ammonia. When distilled by themselves, the volatile oils are partially decomposed; and the gaseous products of the portion decomposed always carry off a little of the oil. When they are mixed with clay or sand, and exposed to a distilling heat, they are in a great measure decomposed; or when they are passed in vapour through a red-hot tube, combustible gases are obtained and a brilliant porous charcoal is deposited in the tube. On the other hand, they distil readily with water, because the aqueous vapour formed at the surface of the boiling fluid carries along with it the vapour of the oil produced in virtue of the tension which it possesses at the 212th deg. Fahr. In the open air, the volatile oils burn with a shining flame, which deposits a great deal of soot. The congealing point of the essential oils varies greatly; some do not solidify till cooled below 32°, others at this point, and some are concrete at the ordinary temperature of the atmosphere. They comport themselves in this respect like the fat oils; and they probably consist, like them, of two different oils, a solid and a fluid; to which the names *stearoptène* and *oleoptène*, or stearessence and oleiessence, may be given. These may be separated from each other by compressing the cool concrete oil between the folds of porous paper; the stearessence remains as a solid upon the paper; the oleiessence penetrates the paper, and may be recovered by distilling it along with water.

When exposed to the air, the volatile oils change their colour, become darker, and gradually absorb oxygen. This absorption commences whenever they are extracted from the plant containing them; it is at first considerable, and diminishes in rapidity as it goes on. Light contributes powerfully to this action, during which the oil disengages a little carbonic acid, but much less than the oxygen absorbed; no water is formed. The oil turns gradually thicker, loses its smell, and is transformed into a resin, which becomes eventually hard. De Saussure found that oil of lavender, recently distilled, had absorbed in four winter months, and at a temperature below 54° F., 52 times its

volume of oxygen, and had disengaged twice its volume of carbonic acid gases; nor was it yet completely saturated with oxygen. The steareness of anise-seed oil absorbed at its liquefying temperature, in the space of two years, 156 times its volume of oxygen gas, and disengaged 26 times its volume of carbonic acid gas. An oil which has begun to experience such an oxidizement is composed of a resin dissolved in the unaltered oil; and the oil may be separated by distilling the solution along with water. To preserve oils in an unchanged state, they must be put in phials, filled to the top, closed with ground glass stopples, and placed in the dark.

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Oil of bitter almonds, is prepared by exposing the bitter almond cake, from which the bland oil has been expressed, in a sieve to the vapour of water rising within the still. The steam, as it passes up through the bruised almond *parenchyma*, carries off its volatile oil, and condenses along with it in the worm. The oil which first comes over, and which falls to the bottom of the water, has so pungent and penetrating a smell, that it is more like cyanogen gas than hydrocyanic or prussic acid. This oil has a golden-yellow colour, it is heavier than water; when much diluted, it has an agreeable smell, and a bitter burning taste. When exposed to the air, it absorbs oxygen, and lets fall a heap of crystals of benzoic acid. This oil consists of a mixture of two oils; one of which is volatile, contains hydrocyanic acid, and is poisonous; the other is less volatile, is not

poisonous, absorbs oxygen, and becomes benzoic acid. If we dissolve 100 parts of the oil of bitter almonds in spirit of wine, mix with the solution an alcoholic solution of potash, and then precipitate the oil with water, we shall obtain a quantity of cyanide of potash, capable of producing $22\frac{1}{2}$ parts of prussian blue. Oil of bitter almonds combines with the alkalis. Perfumers employ a great quantity of this oil in scenting their soaps. One manufacturer in Paris is said to prepare annually 3 cwt. of this oil. A similar poisonous oil is obtained by distilling the following substances with water:—the leaves of the peach (*amygdalus persica*), the leaves of the bay-laurel (*prunus lauro-cerasus*), the bark of the plum tree (*prunus padus*), and the bruised kernels of cherry and plum-stones. All these oils contain hydrocyanic acid, which renders them poisonous, and they also generate benzoic acid, by absorbing oxygen on exposure to air.

Oil of bitter almonds, in the crude state, consists of *hydruret of benzoyle*, *hydrocyanic acid*, *benzoic acid*, and *benzoine*. The two first constituents are essential ones; the others being accidental, and the result of spontaneous reactions.

The hydruret of benzoyle when pure is colourless, transparent, of spec. grav. 1.043; and though it possesses the almond flavour, is not poisonous; it ought to form 85 to 90 per cent. in volume of the crude oil. When oil of vitriol is mixed with that essential oil, it merely gives it a dark reddish brown colour, but does not decompose it. If the said hydruret, however, be exposed to the air, it becomes oxidized, and by the substitution of one atom of oxygen for one of hydrogen, it is transformed into benzoic acid; a compound ~~also~~ present in oil of bitter almonds. This acid is not coloured by oil of vitriol. Benzoine when present however forms a violet coloured compound with sulphuric acid.

Hydrocyanic acid sometimes is present to the extent of 8 or 10 per cent. in crude oil of bitter almonds, rendering the mixture poisonous.

To detect alcohol in oil of bitter almonds, nitric acid of specific gravity 1.42 may be employed, as I did in testing for alcohol in wood spirit.* If the oil be free from alcohol, no immediate action occurs, but in the course of 3 or 4 days crystals of benzoic acid begin to appear, and eventually occupy the whole bulk, giving a bright emerald green colour: this quiet reaction is very characteristic. But if alcohol to the amount of 8 or 10 per cent. be present, a violent effervescence ensues in a few minutes after pouring in the nitric acid, with the disengagement of nitrous fumes. By using nitric acid of 1.5 a very small proportion of alcohol may be recognized.

Essential oil of bitter almonds, free from adulteration, should have a specific gravity at most of 1.052.

When the crude oil of bitter almonds, and a mixture of milk of lime and protochloride of iron are all agitated together, and subjected to distillation at a gentle heat, the product is an oil of bitter almonds free from hydrocyanic acid.

Oil essential of bitter almonds. To determine whether the pure oil of bitter almonds, (hydruret of benzoyle) be poisonous or not, Mr. G. D. Grindley, of the Pharmaceutical school, made the following researches. He at first adopted the usual plan for removing the hydrocyanic acid, by distilling the commercial oil of almonds with a mixture of protochloride of iron and lime; the product was still contaminated with the acid, and several repetitions, conducted with every precaution, were attended with no better success. He then adopted, by the suggestion of Professor Redwood, the following method, which proved most satisfactory. The oil was mixed with an equal quantity of water, and digested in a water bath with red oxide of mercury, and small quantities of lime and protochloride of iron; time having been allowed for the decomposition of the acid, the whole was introduced into a copper retort on account of the jumpings during distillation. The product consisted of pure hydruret of benzoyle, while bicyanide of mercury, benzoate of lime, chloride of calcium, and oxide of iron, remained in the retort, with benzoine and an excess of the ingredients employed. The process is founded upon the strong affinity which exists between mercury and cyanogen, so that when binoxide of mercury and hydrocyanic acid are digested together, they are decomposed, bicyanide of mercury and water being formed. The protochloride of iron, which with the lime yields protoxide, is introduced to prevent the formation of benzoic acid from the oxidation of the oil. For the same reason care should be taken to conduct the process with as little access of air as possible. The oil thus procured was pure and colourless. No trace of nitrogen could be detected by Lassaigne's test, which he found to be exceedingly delicate, affording indications of the presence of that body in extremely minute quantities of morphia, narcotine, &c. This test consists, in adding to a very small quantity of the substance to be tested, in a small German glass tube, a fragment of potassium about the size of a millet seed, and heating the tube over the flame of a spirit lamp, till the organic substance is entirely carbonized. The carbonaceous residue is treated with cold water, and to the clear decanted liquor a drop of a solution containing the mixed two oxides of iron is added. A dirty green precipitate is immediately formed, which if nitro-

* See the pamphlet, *Revenue in Jeopardy*.

gen be present is changed into a bright blue, on the addition of a drop of hydrochloric acid. This pure oil was administered to rabbits without injurious effect on their health or spirits. Bitter almond oil should be always purified by this valuable process of Messrs. Redwood and Grindley.

Oil of anise-seed, is extracted by distillation from the seeds of the *pimpinella anisum*. It is either colourless, or has merely a faint yellow colour, with the smell and taste of the seed. It concretes in lamellar crystals at the temperature of 50°, and does not melt again till heated to 64° nearly. Its specific gravity at 61° is 0.9958, and at 77°, 0.9857. It is soluble in all proportions in alcohol of 0.806; but only to the extent of 42 per cent. in alcohol of 0.84. When it becomes resinous by long exposure to the air, it loses its congealing property. It consists of two oils; a solid steareness, and a liquid oleiessence, which may be separated by compression of the cold concrete oil.

Oil of bergamot, is extracted by pressure from the rind of the ripe fruit of the *citrus bergamium* and *aurantium*. It is a limpid, yellowish fluid, having a smell resembling that of oranges. Its specific gravity varies from 0.888 to 0.885. It becomes concrete when cooled a little below 32°.

Oil of cajeput is prepared in the Moluccas, by distilling the dry leaves of the *melaleuca leucadendron*. Cajeput is a native word, signifying merely a white tree. This oil is green; it has a burning taste, a strong smell of camphor, turpentine, and savine. It is very fluid, and at 48° has a specific gravity of 0.948. The colour seems to be derived from the copper vessels in which it is imported, so that it is removed by distillation with water, which also separates the oil into two sorts; the first which comes over having a density of 0.897, the last of 0.920. This has a green colour.

The *oil of caraway* is extracted from the seeds of the *carum carvi*. It has a pale yellow colour and the smell and taste of the plant. Its specific gravity is 0.960. The seeds of the *caminum cymium* (cumin) afford an oil similar to the preceding, but not so agreeable. Its specific gravity is 0.975.

The *oil of cassia*, from the *laurus cassia*, is yellow passing into brown, has a specific gravity of 1.071, and affords a crystalline steareness by keeping in a somewhat open vessel.

The *oil of chamomile* is extracted by distillation from the flowers of the *matricaria chamomilla*. It has a deep blue colour, is almost opaque, and thick, and possesses the peculiar smell of the plant. In the atmosphere it becomes brown and unctuous. If an ounce of oil of lemons be added to 3 pounds of this oil, they make it separate more readily from the adhering water.

Other blue oils, having much analogy with oil of chamomile, are obtained by distilling the following plants: roman chamomile (*anthemis nobilis*), the flowers of *arnica montana*, and those of milfoil (*achillea millefolia*). The last has a spec. grav. of 0.852.

Oil of cinnamon, is extracted by distillation from the bark of the *laurus cinnamomum*. It is produced chiefly in Ceylon, from the pieces of bark unfit for exportation. It is distilled over with difficulty, and the process is promoted by the addition of salt water, and the use of a low still. It has at first a pale yellow colour, but it becomes brown with age. It possesses in a high degree both the sweet burning taste and the agreeable smell of cinnamon. It is heavier than water: its specific gravity being 1.035. It concretes below 32° F., and does not fuse again till heated to 41°. It is very sparingly soluble in water, and when agitated with it readily separates by repose. It dissolves abundantly in alcohol, and combines with ammonia into a viscid mass, not decomposed on exposure to air.

When oil of cinnamon is kept for a long time, it deposits a steareness in large regular colourless or yellow crystals, which may be pulverized, and which melt at a very gentle heat into a colourless liquid, which crystallizes on cooling. It has an odour intermediate between that of cinnamon and vanilla; and a taste at first greasy, but afterwards burning and aromatic. It crackles between the teeth. It requires a high temperature for distillation, and becomes then brown and empyreumatic. It is very soluble in alcohol.

The *oil of cloves*, is extracted from the dried flower buds of the *caryophyllus aromaticus*. It is colourless, or yellowish, has a strong smell of the cloves, and a burning taste. Its specific gravity is 1.061. It is one of the least volatile oils, and the most difficult to distil. At the end of a certain time it deposits a crystalline concrete oil. A similar steareness is obtained by boiling the bruised cloves in alcohol, and letting the solution cool. The crystals thus formed are brilliant, white, grouped in globules, without taste and smell. Oil of cloves has remarkable chemical properties. It dissolves in alcohol, ether, and acetic acid. It does not solidify at a temperature of 4° under 0° F., even when exposed to that cold for several hours. It absorbs chlorine gas, becomes green, then brown, and turns resinous. Nitric acid makes it red, and if heated upon it, converts it into oxalic acid. If mixed by slow degrees with one third of its weight of sulphuric acid, an acid liquor is formed, at whose bottom a resin of a fine purple colour

is found. After being washed, this resin becomes hard and brittle. Alcohol dissolves it, and takes a red colour; and water precipitates it of a blood red hue. It dissolves also in ether. When we agitate a mixture of strong caustic soda lye and oil of cloves in equal parts, the mass thickens very soon, and forms delicate lamellar crystals. If we then pour water upon it, and distil, there passes along with the water a small quantity of an oil which differs from oil of cloves both in taste and chemical properties. During the cooling, the liquor left in the retort lets fall a quantity of crystalline needles, which being separated by expression from the alkaline liquid, are almost inodorous, but possess an alkaline taste, joined to the burning taste of the oil. These crystals require for solution from 10 to 12 parts of cold water. Potash lye produces similar effects. Ammoniacal gas transmitted through the oil is absorbed and makes it thick. The concrete combination thus formed remains solid as long as the phial containing it is corked, but when opened, the compound becomes liquid; and these phenomena may be reproduced as many times as we please. Such combinations are decomposed by acids, and the oil set at liberty has the same taste and smell as at first, but it has a deep red colour. The alkalis enable us to detect the presence of other oils, as that of turpentine or sassafras, in that of cloves, because they fix the latter, while the former may be volatilized with water by distilling the mixture. The oil of cloves found in commerce is not pure, but contains a mixture of the tincture of pinks or clove-gilly flowers, whose acrid resin is thereby introduced. It is sometimes sophisticated with other oils.

The oil of elder, is extracted by distillation from the flowers of the *sambucus nigra*. It has the consistence of butter. The watery solution is used in medicine.

Oil of fennel, is extracted by distillation from the seeds of the *anethum feniculum*. It is either colourless or of a yellow tint, has the smell of the plant, and a specific gravity of 0.997. When treated with nitric acid, it affords benzoïn. It congeals at the temperature of 14° F., and then yields by pressure a solid and a liquid oil; the former appearing in crystalline plates. It is used in this country for scenting soap.

Oils of fermented liquors. The substances usually fermented contain a small quantity of essential oils, which become volatile along with the alcoholic vapours in distillation, and progressively increase as the spirits become weaker towards the end of the process. The vapours then condense into a milky liquor. These oils adhere strongly to the alcohol, and give it a peculiar acrid taste. They differ according to the vinous wash from which they are obtained, and combine with greater or less facility with caustic alkalis.

2. Oil of grain spirits. At the ordinary temperature it is partially a white solid; when cooled lower it assumes the aspect of suet, and therefore consists chiefly of stear-seance. Its taste and smell are most offensive; it swims upon the surface of water, and even of spirit containing 30 per cent. of alcohol. It sometimes derives a green colour from the copper worm of the still. When heated it fuses and turns yellow. When it has become resinous by the agency of the atmosphere, it gives a greasy stain to paper. It dissolves in 6 parts of anhydrous alcohol, and in 2 of ether; and it is said to crystallize when the spirit solution has been saturated with it hot, and is allowed to cool. By exposure to a freezing mixture, the whisky which contains it lets it fall. Caustic potash dissolves it very slowly, and forms a soap soluble in 60 parts of water. It is absorbed by wood charcoal, and still better by bone black; whereby it may be completely abstracted from bad whisky. According to Buchner, another oil may also be obtained from the residuum of the second distillation of whisky, if saturated with sea-salt, and again distilled. Thus we obtain a pale yellow fluid oil, which does not concrete with cold, possessed of a disagreeable smell and acrid taste. Its specific gravity is 0.835. It is soluble in alcohol and ether.

2. The oil from potato spirits, has properties quite different from the preceding. It is obtained in considerable quantity by continuing the distillation after most of the alcohol has come over, and it appears in the form of a yellowish oil, mixed with water and spirits. After being agitated first with water, then with a strong solution of muriate of lime, and distilled afresh, it possesses the following properties: it is colourless, limpid, has a peculiar smell, and a bitter hot taste of considerable permanence. It leaves no greasy stain upon paper, remains liquid at 0° F., but cooled below that point it crystallizes like oil of anise-seed. When pure it boils at 257° F.; but at a lower degree, if it contains alcohol. Its specific gravity is 0.821 or 0.823, when it contains a little water. It burns with a clear flame without smoke, but it easily goes out, if not burned with a wick. It dissolves in small quantity in water, to which it imparts its taste and the properties of forming a lather by agitation. It dissolves in all proportions in alcohol. Chlorine renders it green. Concentrated sulphuric acid converts it into a crimson solution, from which it is precipitated yellow by water. It dissolves in all proportions in acetic acid. Concentrated caustic lyes dissolve it, but give it up to water. It does not appear to be poisonous, like the oil of corn spirits; because, when given by spoonfuls to dogs, it produced no other effect but vomiting.

3. *The oil of brandy or grape spirits*, is obtained during the distillation of the fermented residuum of expressed grapes; being produced immediately after the spirituous liquor has passed over. It is very fluid, limpid, of a penetrating odour, and an acrid disagreeable taste. It grows soon yellow in the air. When this oil is distilled, the first portions of it pass unchanged, but afterwards it is decomposed and becomes empyreumatic. It dissolves in 1000 parts of water, and communicates to it its peculiar taste and smell. One drop of it is capable of giving a disagreeable flavour to ten old English gallons of spirits. It combines with the caustic alkalis, and dissolves sulphur.

Oil of juniper, is obtained by distilling juniper berries along with water. These should be bruised, because their oil is contained in small sacs or reservoirs, which must be laid open before the oil can escape. It is limpid and colourless, or sometimes of a faint greenish yellow colour. Its specific gravity is 0.911. It has the smell and taste of the juniper. Water, or even alcohol, dissolves very little of it. Gin contains a very minute quantity of this oil. Like oil of turpentine, it imparts to the urine of persons who swallow it the smell of violets. Oil of juniper is frequently sophisticated with oil of turpentine introduced into the still with the berries; a fraud easily detected by the diminished density of the mixture.

The oil of lavender, is extracted from the flowering spike of the *lavandula spica*. It is yellow, very fluid, has a strong odour of the lavender, and a burning taste. The specific gravity of the oil found in commerce is 0.898 at the temperature of 72° F., and of 0.877 when it has been rectified. It is soluble in all proportions in alcohol of 0.830, but alcohol of 0.887 dissolves only 42 per cent. of its weight. The fresh oil detonates slightly when mixed with iodine, with the production of a yellow cloud. There occurs in commerce a kind of oil of lavender known under the name of oil of *aspic* or oil of *spike*, extracted by distillation from a wild variety of the *lavandula spica* which has large leaves, and is therefore called *latifolia*. This oil is manufactured in the south of Europe. Its odour is less characteristic than that of the lavender, resembling somewhat that of oil of turpentine, with which it is indeed often adulterated. It is also so cheap as to be sometimes used instead of the latter oil. Oil of lavender deposits, when partially exposed to the air, a concrete oil, which resembles camphor, to the amount of one fourth of its weight.

Oil of lemons, is extracted by pressure from the yellow peel of the fruit of the lemon, or *citrus medica*. In this state it is a yellowish fluid, having a specific gravity of 0.8517; but when distilled along with water till three fifths of the oil have come over, it is obtained in a colourless state, and of a specific gravity of 0.847 at 72° F. This oil does not concrete till cooled to 4° below 0° F.

The oil of lemons has a very agreeable smell of the fruit, which is injured by distillation. It is soluble in all proportions in anhydrous alcohol, but only 14 parts dissolve in 100 of spirits of wine of specific gravity 0.837. This oil, especially when distilled, forms with muriatic acid similar camphorated compounds with oil of turpentine, absorbing no less than 280 volumes of the acid gas.

Oil of lemons kept long, in ill-corked bottles, generates a quantity of stearseance, which when dissolved in alcohol, precipitated by water, and evaporated, affords brilliant, colourless, transparent needles. Some acetic acid is also generated in the old oil. According to Brandes, the specific gravity of oil of lemons is 0.8786.

The oil of mace, lets fall, after a certain time, a concrete oil under the form of a crystalline crust, called by John *myristicine*.

The oil of nutmegs, is extracted chiefly from mace, which is the inner epidermis of these nuts. It is colourless, or yellowish, a little viscid with a strong aromatic odour of nutmegs, an acrid taste, and a specific gravity of 0.948. It consists of two oils, which may be easily separated from each other by agitation with water; for one of them, which is more volatile and aromatic, comes to the surface, while the other, which is denser, white, and of a buttery consistence, falls to the bottom. The latter liquefies by the heat of the hand.

The oil of orange flowers, called *neroli*, is extracted from the fresh flowers of the *citrus aurantium*. When recently prepared it is yellow; but when exposed for two hours to the rays of the sun, or for a longer time to diffuse daylight, it becomes of a yellowish-red. It is very fluid, lighter than water, and has a most agreeable smell. The aqueous solution, known under the name of orange-flower water, is used as a perfume. It is obtained either by dissolving the oil in water, or by distilling with water the leaves either fresh or salted; the first being the stronger, but the last being the more fragrant preparation. Orange-flower water obtained by distillation contains, besides the oil, a principle which comes over with it, of a nature hitherto unknown; it possesses the property of imparting to water the faculty of becoming red with a few drops of sulphuric acid. The water formed from the oil alone is destitute of this property. The intensity of the rose-colour is a test in some measure of the richness of the water in oil.

The oil of parsley, is extracted from the *apium petroselinum*. It is of a pale yellow

colour, having the smell of the plant, and consists of two oils separable by agitation in water. Its liquid part floats upon the surface in a very fluid form: its steareness, which falls to the bottom, is butyraceous and crystallizes at a low temperature. This concrete oil melts at 86° F.

The oil of pepper, is extracted from the *piper nigrum*. In the recent state it is limpid and colourless, but by keeping it becomes yellow. It swims upon the surface of water. In odour it resembles pepper, but is devoid of its hot taste.

The oil of peppermint is extracted from the *mentha piperita*. It is yellowish and ends with a very acrid burning taste. Its specific gravity is 0.920. At 6° or 7° below 0° F., it deposits small capillary crystals. After long keeping it affords a steareness resembling camphor, provided the oil had been obtained from the dry plant gathered in flower, but not from distillation of the fresh plant. When artificially cooled, it yields 6 per cent. of steareness, which crystallizes in prisms with three sides, has an acrid somewhat rank taste, is soluble in ether and alcohol, and is thrown down from the latter solution by water in the form of a white powder. Peppermint water is characterised by the sensation of coolness which it diffuses in the mouth.

The oil of pimento, is extracted from the envelopes of the fruits of the *myrtus pimenta*, which affords 8 per cent. of it. It is yellowish, almost colourless, of a smell analogous to that of cloves, an acrid burning taste, and a specific gravity greater than water. Nitric acid makes it first red, and after the effervescence, of a rusty brown hue. It combines with the salifiable bases, like oil of cloves.

The oil of rhodium, is extracted from the wood of the *convolvulus scoparius*. It is very fluid, and has a yellow colour, which in time becomes red. It has somewhat of the rose odour; and is used to adulterate the genuine otto. Its taste is bitter and aromatic, which it imparts to the otto as well as its fluidity.

The oil of roses, called also the *attar* or *otto*, is extracted by distillation from the petals of the *rosa centifolia* and *sempervirens*. Our native roses furnish such small quantities of the oil, that they are not worth distilling for the purpose. The best way of operating is to return the distilled water repeatedly upon fresh petals, and eventually to cool the saturated water with ice; whereby a little butyraceous oil is deposited. But the oil thus obtained has not a very agreeable odour, being injured by the action of the air in the repeated distillations. In the East Indies, the attar is obtained by stratifying rose leaves in earthen pans in alternate layers, with the oleiferous seeds of a species of digitalis, called *gengeti*, for several days, in a cool situation. The fat oil of the seed absorbs the essential oil of the rose. By repeating this process with fresh leaves and the same seed, this becomes eventually swollen, and being then expressed furnishes the oil. The turbid liquid thus obtained is left at rest, in well-closed vessels, where it gets clarified. The layer of oil that floats on the top is then drawn off by a capillary cotton wick, and subjected to distillation along with water, whereby the volatile otto is separated from the fat seed-oil.

The oil of roses is colourless, and possesses the smell of roses, which is not, however, agreeable, unless when diffused, for in its concentrated state it is far from pleasant to the nostrils, and is apt to occasion headaches. Its taste is bland and sweetish. It is lighter than water, and at the temperature of 92°, its specific gravity compared to that of water at 60° is 0.832. At lower temperatures it becomes concrete and butyraceous; and afterwards fuses at 90°. It is but slightly soluble in alcohol; 1000 parts of this liquid at 0.806 dissolving only 7½ parts at 58° F. This oil consists of two parts, the steareness and oleiessence; the latter being the more volatile odoriferous portion.

The oil of rosemary, is extracted from the *rosmarinus officinalis*. It is as limpid as water, has the smell of the plant, and in other respects resembles oil of turpentine. The oil found in commerce has a specific gravity of 0.911, which becomes 0.8886 by rectification. It boils at 320° F. (occasionally at 329°). It is soluble in all portions in alcohol of 0.830. When kept in imperfectly closed vessels, it deposits a steareness to the amount of one tenth of its weight, resembling camphor. It is sometimes adulterated with oil of turpentine, a fraud easily detected by adding anhydrous alcohol, which dissolves only the oil of rosemary.

The oil of saffron, is extracted from the *stigmata* of the *crocus sativus*. It is yellow, very fluid, falls to the bottom of water, diffuses the penetrating odour of the plant, and has an acrid and bitter taste. It is narcotic.

The oil of sassafras is extracted from the woody root of the *lasurus sassafras*. It is colourless, but at the end of a certain time it becomes yellow or red. It has a peculiar, sweetish, pretty agreeable, but somewhat burning taste. Its specific gravity is 1.094. According to Bonastre, this oil separates by agitation with water into an oil lighter and

an oil heavier than this fluid. When long kept, it deposits a stearessence in transparent and colourless crystals, which have the smell and taste of the liquid oil.

The oil of savine, is extracted from the leaves of the *juniperus sabina*. It is limpid, and has the odour and taste of the plant, which is one more productive of volatile oil than any other.

The oil of tansy has a specific gravity of 0.946, the penetrating odour of the *tanacetum vulgare*, with an acrid and bitter taste.

Oil of turpentine, commonly called essence of turpentine. It is extracted from several species of turpentine, a semi-liquid resinous substance which exudes from certain trees of the pine tribe, and is obtained by distilling the resin along with water. This oil is the cheapest of all the volatile species, and, as commonly sold, contains a little resin, from which it may be freed by re-distillation with water. It is colourless, limpid, very fluid, and has a very peculiar smell. Its specific gravity at 60° is 0.872; that of the spirit on sale in the shops is 0.876. This oil always reddens litmus paper, because it contains a little succinic acid.

100 parts of spirits of wine, of specific gravity 0.84, dissolve only 13½ of oil of turpentine at 72° F. When agitated with alcohol at 0.830 the oil retains afterwards one fifth of its bulk of the spirit; hence this proposed method for purifying oil of turpentine is defective. The oil, if left during four months in contact with air, is capable of absorbing 20 times its bulk of oxygen gas. One volume of rectified oil of turpentine absorbs at the temperature of 72°, and under the common atmospheric pressure, 163 times its volume of muriatic acid gas, provided the vessel be kept cool with ice. This mixture being allowed to repose for 24 hours, produces out of the oil from 26 to 47 per cent. of a white crystalline substance, which subsides to the bottom of a brown, smoking, translucent liquor. Others say that 100 parts of oil of turpentine yield 110 of this crystalline matter, which was called by Kind, its discoverer, artificial camphor, from its resemblance in smell and appearance to this substance. Both the solid and the liquid are combinations of muriatic acid and oil of turpentine; indicating the existence of a stearine and an oleine in the latter substance. The liquid compound is lighter than water, and is not decomposed by it, nor does it furnish any more solid matter when more muriatic gas is passed through it. The solid compound, after being washed first with water containing a little carbonate of soda, then with pure water, and finally purified by sublimation with some chalk, lime, ashes, or charcoal, appears as a white, translucent, crystalline body, in the form of flexible, tenacious needles. It swims upon the surface of water, diffuses a faint smell of camphor, commonly mixed with that of oil of turpentine, and has rather an aromatic than a camphorated taste. It does not redden litmus paper. Water dissolves a very minute quantity; but cold alcohol of 0.806 dissolves fully one third of its weight, and hot much more, depositing as it cools this excess in the form of crystals. The solution is not precipitated by nitrate of silver, which shows that the nature of the muriatic acid is perfectly masked by the combination. It is composed, in 100 parts, of 76.4 carbon, 9.6 hydrogen, and 14 muriatic acid. The muriatic acid, or chlorine, may be separated by distilling an alcoholic solution of the artificial camphor 12 or 14 times in succession with slaked lime.

Oil of turpentine is best preserved in casks enclosed within others, with water between the two. Its principal use is for making varnishes, and as a remedy for the tape-worm.

The oil of thyme, is extracted from the *thymus serpyllum*. It is reddish yellow, has an agreeable smell, and, after being long kept, it lets fall a crystalline stearessence. It is used merely as a perfume.

The oil of wormwood, is extracted from the *artemisia absinthium*. It is yellow, or sometimes green, and possesses the odour of the plant. Its taste resembles that of wormwood, but without its bitterness. Its specific gravity is 0.9703 according to Brisson, and 0.9725 according to Brandes. It detonates with iodine when it is fresh. Treated with nitric acid of 1.25 specific gravity, it becomes first blue, and after some time brown.

The numerous uses of unctuous oils give importance to their preparation, as articles of food, or for burning in lamps, and for the manufacture of soaps, &c. The seeds most productive of oil are those of colza (a species of cabbage, *brassica arvensis*), rape, mustard, sesamum, poppy, linseed, hemp, and beech mast. Nuts afford an oil that is much esteemed for certain purposes, and may be easily obtained by pressure. The following Table indicates the quantities of oil which can be extracted from different fruits, and some other substances:—

| 100 Parts of each. | Oil per Cent. | 100 Parts of each. | Oil per Cent. |
|--------------------------|---------------|--------------------------------|---------------|
| Walnuts - - - | 40 to 70 | Wild mustard seed - | 30 |
| Castor-oil seeds - - | 62 | Camelina seed - - - | 28 |
| Hazel nuts - - - | 60 | Weld seed - - - | 29 to 36 |
| Garden cress seed - - | 56 to 58 | Gourd seed - - - | 25 |
| Sweet almonds - - - | 40 to 54 | Lemon seed - - - | 25 |
| Bitter almonds - - - | 28 to 46 | Onocardium <i>acanthæ</i> , or | |
| Poppy seeds - - - | 56 to 63 | bear's foot - - - | 25 |
| Oily radish seed - - | 50 | Hemp seed - - - | 14 to 25 |
| Sesamum (jugoline) | 50 | Linseed - - - | 11 to 22 |
| Lime-tree seeds - - | 48 | Black mustard seed - | 15 |
| Cabbage seed - - - | 30 to 39 | Beech mast - - - | 15 to 17 |
| White mustard - - - | 36 to 38 | Sunflower seeds - - - | 15 |
| Rape, colewort, and Swe- | | Stramonium, or thorn- | |
| dish turnip seeds - | 33·5 | apple, seeds - - - | 15 |
| Plum kernels - - - | 33·3 | Grape-stones - - - | 14 to 22 |
| Colza seed - - - | 36 to 40 | Horse-chestnuts - - - | 1·2 to 8 |
| Rape seed - - - | 50 to 36 | St. Julian Plum - - - | 18 |
| Euphorbium (spurge seed) | 30 | | |

To obtain the above proportions of oil, the fruits must be all of good quality, deprived of their pods, coats, or *involucra*, and of all the parts destitute of oil, which also must be extracted in the best manner.

The following Table is given by M. Dumas, as exhibiting the practical results of the French seed oil manufacturers: —

| | Weight per Hectollitre. | Produce in Litres. |
|---------------------------|-------------------------|--------------------|
| Summer Colza - - - | 54 to 65 kiloga. | 21 to 25 |
| Winter Colza - - - | 56 to 70 — | 25 to 28 |
| Rape seed - - - | 55 to 68 — | 23 to 26 |
| Camelina seed - - - | 53 to 60 — | 20 to 24 |
| Poppy seed - - - | 54 to 62 — | 22 to 25 |
| <i>Madia sativa</i> - - - | 40 to 50 — | 12 to 15 |
| Beech mast - - - | 42 to 50 — | 12 to 15 |
| Hemp seed - - - | 42 to 50 — | 12 to 15 |
| Linseed - - - | By sample, 67. | 10 to 12 |
| Stripped walnuts - - | From 100 kiloga. | 46 to 50 |
| Sweet almonds - - - | — 100 — | 44 to 48 |
| Olives - - - | — 100 — | 10 to 12 |

Colza, rapeseed, and cameline oils are employed for lamps; poppy, *madia sativa*, are employed, when recent, as articles of food—or for soaps and paintings; hemp-seed and linseed for painting, soft soaps, and for printers' ink; walnut oil, for food, painting, and lamps; olive oil, for food, soaps, lamps.

In extracting oil from seeds, two processes are required — 1st, *trituration*; 2d, *expression*; and the steps are as follows: —

1. Bruising under revolving heavy-edge millstones, in a circular bed, or trough of iron, bedded on granite.
2. Heating of the bruised seeds, by the heat either of a naked fire or of steam.
3. First pressure or crushing of the seeds, either by wedges, screw, or hydraulic presses.

4. Second crushing of the seed cakes of the first pressure.

5. Heating the bruised cakes; and, 6., a final crushing.

The seeds are now very generally crushed, first of all between two iron cylinders revolving in opposite directions, and fed in from a hopper above them; after which they yield more completely to the triturating action of the edge stones, which are usually hooped round with a massive iron ring. A pair of edge millstones of about 7 or 7½ feet in diameter, and 25 or 26 inches thick, weighing from 7 to 8 tons, can crush, in 12 hours, from 2½ to 3 tons of seeds. The edge-millstones serve not merely to grind the seeds at first, but to triturate the cakes after they have been crushed in the press. Old dry seeds sometimes require to be sprinkled with a little water to make the oil come more freely away; but this practice requires great care.

The apparatus for heating the bruised seeds consists usually of cast iron or copper

pans, with stirrers moved by machinery. *Figs. 1016, 1017, 1018, 1019.* represent the heaters by naked fire, as mounted in Messrs. Maudsley and Field's excellent seed crushing mills, on the wedge or Dutch plan.

Fig. 1016. is an elevation, or side view of the fire-place of a naked heater; *fig. 1017.* is a plan, in the line *uv* of *fig. 1016.* *Fig. 1018.* is an elevation and section parallel to the line *vv* of *fig. 1017.* *Fig. 1019.* is a plan of the furnace, taken above the grate of the fire-place.

A, fire-place shut at top by the cast-iron plate *B*; called the fire-plate.

C, iron ring-pan, resting on the plate *B*, for holding the seeds; which is kept in its place by the pins or bolts *a*.

D, funnels, *britches*, into which by pulling the ring-case *E*, by the handles *b b*, the seeds are made to fall, from which they pass into bags suspended to the hooks *e*.

F, *fig. 1018.*, the stirrer which prevents the seeds from being burned by continued contact with the hot plate. It is attached by a turning-joint to the collar *F*, which turns with the shaft *G*, and slides up and down upon it. *H,* a bevel wheel, in gear with the bevel wheel *I*, and giving motion to the shaft *G*.

K, a lever for lifting up the agitator or stirrer *F*. *L,* a catch for holding up the lever *K*, when it has been raised to a proper height.

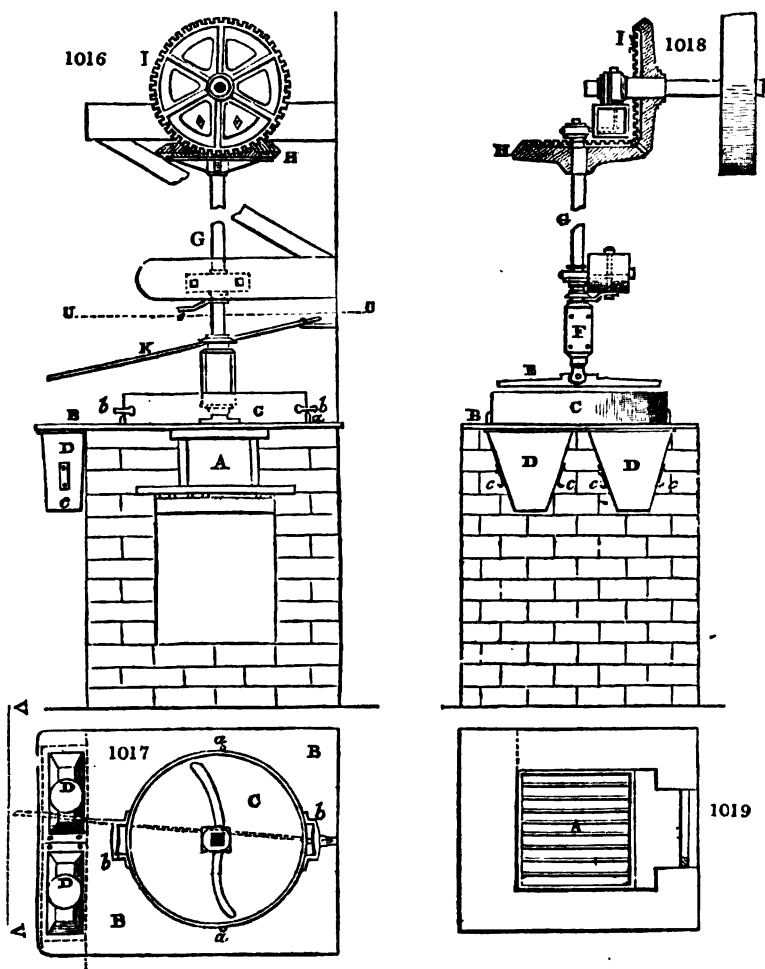
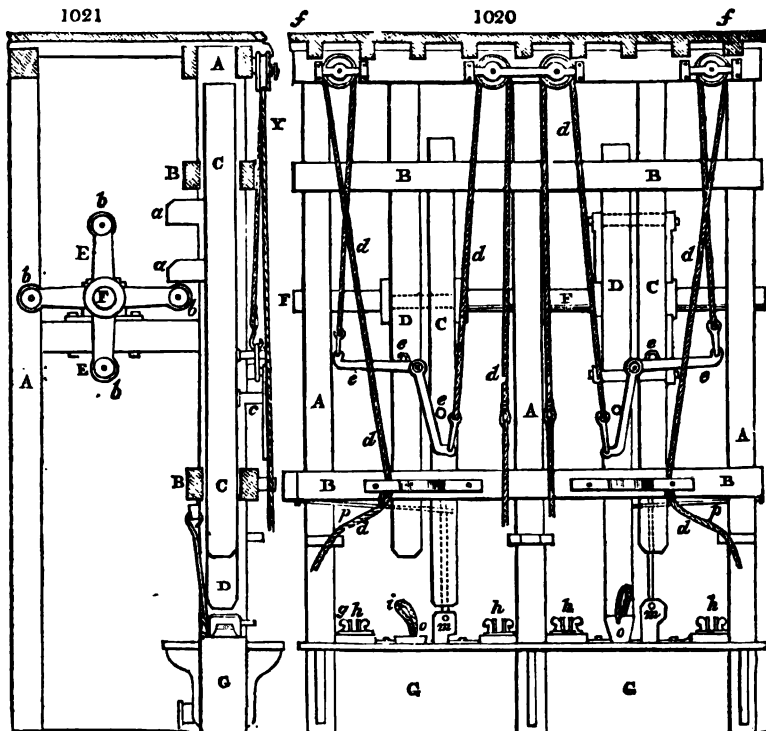


Fig. 1020., front elevation of the wedge seed-crushing machine, or wedge-press.
Fig. 1021. section, in the line xx of fig. 1022.

Fig. 1022., horizontal section, in the line vv, of fig. 1021.

A, A. Upright guides, or framework of wood.



n, n. Side guide-rails.

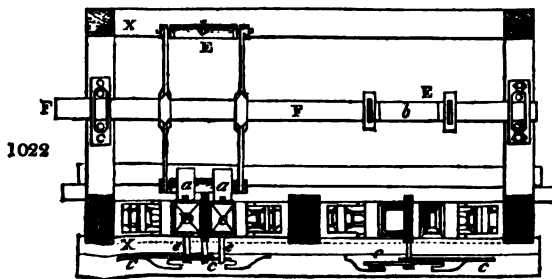
n, Driving stamper of wood, which presses out the oil; c, spring stamper, or relieving wedge, to permit the bag to be taken out when sufficiently pressed. x is the lifting shaft, having rollers, b, b, b, b, fig. 1021., which lift the stampers by the cams, a a, fig. 1021. r is the shaft from the power-engine, on which the lifters are fixed.

a is the cast-iron press-box, in which the bags of seed are placed for pressure, laterally by the force of the wedge.

o, figs. 1019. and 1023.; the spring, or relieving wedge.

e, lighter rail; d, lifting-rope to ditto.

f, f, f, flooring overhead.



g, figs. 1019, & 1023. † the back iron, or end-plate minutely perforated.

h, the horse-hair bags (called hairs), containing the flannel bag, charged with seed;

i, the dam-block; *m*, the spring wedge.

Fig. 1022. *λ*, upright guides; *c*, and *n*, spring and driving stampers; *z*, lifting roller;

r, lifting shaft; *aa*, cams of stampers.

Fig. 1023., a view of one set of the wedge-boxes, or presses; supposing the front of them to be removed.

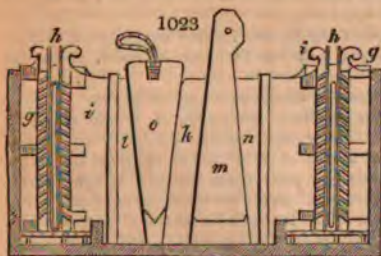


Fig. 1023.; *o*, driving-wedge; *g*, back iron; *h*, hairs; *i*, dam-block; *l*, speering or oblique block, between the two stampers; *l*, ditto; *n*, ditto; *m*, spring wedge.

When, in the course of a few minutes, the bruised seeds are sufficiently heated in the pans, the double door *FF* is withdrawn, and they are received in the bags, below the aperture *a*. These bags are made of strong twilled woollen cloth, woven on purpose. They are then wrapped in a hair-cloth, lined with leather.

The first pressure requires only a dozen blows of the stamper, after which the pouches are left alone for a few minutes till the oil has had time to flow out; in which interval the workmen prepare fresh bags. The former are then unlocked, by making the stamper fall upon the loosening wedge or key, *m*.

The weight of the stampers is usually from 500 to 600 pounds; and the height from which they fall upon the wedges is from 16 to 21 inches.

Such a mill as that now described can produce a pressure of from 50 to 75 tons upon each cake of the following dimensions:—8 inches in the broader base, 7 inches in the narrower, 18 inches in the height; altogether nearly 140 square inches in surface, and about $\frac{3}{4}$ of an inch thick.

OILS, ADULTERATION OF. M. Heidenreich has found in the application of a few drops of sulphuric acid to a film of oil, upon a glass plate, a means of ascertaining its purity. The glass plate should be laid upon a sheet of white paper, and a drop of the acid let fall on the middle of ten drops of the oil to be tried.

With the *oil of rape-seed* and *turnip-seed*, a greenish blue ring is gradually formed at a certain distance from the acid, and some yellowish brown bands proceed from the centre.

With *oil of black mustard*, in double the above quantity, also a bluish green colour.

With *whale and cod-oil*, a peculiar centrifugal motion, then a red colour, increasing gradually in intensity; and after some time, it becomes violet on the edges.

With *oil of cameline*, a red colour, passing into bright yellow.

Olive-oil, pale yellow, into yellowish green.

Oil of poppies and sweet almonds, canary yellow, passing into an opaque yellow.

Of linseed, a brown magma, becoming black.

Of tallow or oleine, a brown colour.

In testing oils, a sample of the oil imagined to be present should be placed alongside of the actual oil, and both be compared in their reactions with the acid. A good way of approximating to the knowledge of an oil is by heating it, when its peculiar odour becomes more sensible.

Specific gravity is also a good criterion. The following table is given by M. Heidenreich:—

| | Sp. Gr. | Gay-Lussac's Alcoholm. |
|----------------------------|---------|------------------------|
| Oleine or Tallow Oil - - - | 0.9003 | 66 |
| Oil of Turnip Seed - - - | 0.9128 | 60½ |
| Rape Oil - - - - - | 0.9136 | 60½ |
| Olive Oil - - - - - | 0.9176 | 58½ |
| Purified Whale Oil - - - | 0.9231 | 55½ |
| Oil of Poppies - - - - | 0.9243 | 55½ |
| Oil of Camelina - - - - | 0.9252 | 54½ |
| Linseed Oil - - - - - | 0.9347 | 50 |
| Castor Oil - - - - - | 0.9611 | 33½ |

M. Laurot, a Parisian chemist, finds that colza oil (analogous to rapeseed oil) may be tested for sophistication with cheaper vegetable oils by the increase of density

which it therefrom acquires, and which becomes very evident when the several oils are heated to the same pitch. The instrument, which he calls an *oleometer*, is merely a hydrometer, with a very slender stem. He plunges it into a tin cylinder filled with the oil, and sets this cylinder in another containing boiling water. His oleometer is so graduated as to sink to zero in pure colza oil so heated; and he finds that it stops at 210° in linseed oil, at 124° in poppy-seed oil, at 83° in fish oil, and at 136° in hemp-seed oil—all of the same temperature. By the increase of density, therefore, or the ascent of the stem of the hydrometer in any kind of colza oil, he can infer its degree of adulteration.

The presence of a fish oil in a vegetable oil is readily ascertained by agitation with a little chlorine gas, which blackens the fish oil, but has little or no effect upon the vegetable oil.

I find that lard oil, and also hogs'-lard, are not at all darkened by chlorine.

A specific gravity bottle or globe, having a capillary tube-stopper, would make an excellent oleometer, on the above principle. The vessel should be filled with the oil, and exposed to the heat of boiling water or steam at 212°, till it acquires that temperature, and then weighed. The vessel with the pure colza oil will weigh several grains less than with the other oils similarly treated. Such an instrument would serve to detect the smallest adulterations of sperm oil. Its specific gravity at 60° when pure is only 0.875; that of southern whale oil is 0.922, or 0.925; and hence their mixture will give a specific gravity intermediate, according to the proportion in the mixture. Thus I have been enabled to detect sperm oil in pretended lard oil, in my examination of oils for the customs.

OILS ESSENTIAL. *Tests of Purity.* 1. *Ol. Amygdalarum amar.* (*Bitter Almonds*). This oil possesses, besides its *specific gravity* and peculiar smell, so many striking chemical characteristics, that any adulteration of it must be easily detected. To these characteristics belong its great clear solubility in *sulphuric acid*, with a reddish brown coloration and without any visible decomposition; the very slow action which *nitric acid* has upon it, without either of the two substances undergoing any change in its physical properties; the only partial slow solution of *iodine* without further reaction; the indifference to *chromate of potash*; the elimination of crystals from its solution in an *alcoholic solution of caustic potash*; the peculiar inspissation by *caustic ammonia* and *muric acid*, and the elimination of crystals from the alcoholic solutions of these new compounds, and, lastly, the decidedly *acid reaction*; in short, almost by every reagent some peculiarity of this oil is displayed, by which its purity can be perfectly and easily established.

2. *Ol. Caryophyllorum* (*Cloves*). The properties which this oil possesses afford great opportunity of discovering its purity. Firstly, its relation to the *alcoholic solution of caustic potash*, with which it congeals entirely into a crystalline mass, *totally losing at the same time the clove odour*. Any foreign substance present would be excluded from this compound, or would interrupt and weaken it. Similar to this, and equally marked, is the butyraceous coagulum, which is obtained by shaking the oil with a solution of caustic ammonia, and which, after fusion, crystallizes. The *spontaneous* ready decomposition by *nitric acid*, and simultaneous formation of a reddish brown solid mass, as also the *dark blue* coloration of the oil by a small quantity of *sulphuric acid*, whilst a greater portion of the latter changes the oil into a blood red solid mass, are equally striking tests. To these we may add the *perfect decomposition* of the oil into brown flakes by *chromate of potash*, accompanied by the *loss of the yellow colour* of the solution of this salt; the solubility of *iodine*, which forms with it a liquid extract, with but a small increase of temperature, and also the *perfect* and easy solubility of *santaline* in it.

3. *Ol. Cinnamomi* (*Cinnamon*). With this oil the question is not merely to detect an adulteration with other oils, but also to distinguish the two sorts of this oil from one another, viz., the Ceylon oil (*oleum cinnamomi verum*) and the Chinese oil (*oleum cassia*) which differ very much in price. In both cases it is difficult to obtain accurate tests of the properties of these oils, as they are almost exclusively obtained by way of commerce, and vary considerably in their qualities, on account of their age and careless method of preparation. The chief distinction between the two oils is the *odour*: the Ceylon oil is, moreover, more liquid, and of a less specific weight than the Chinese, and may be exposed to a greater degree of cold than the latter without becoming turbid. The most distinguishing characteristic of the cinnamon oils is, perhaps, their relation to the alcoholic solution of caustic potash: both dissolve in it readily and clear, with a reddish yellowish brown colour; after some time, however, the solution becomes *very turbid*, and a rather heavy undissolved oil precipitates, whilst the solution gradually becomes clear again.

Another peculiar character is, where the oil is being decomposed by *nitric acid*, a smell of bitter almond oil is perceptible. Both oils are at the same time converted into a brown balsam; in the Ceylon oil a brisk decomposition occurs sooner, and at a slighter heat.

Iodine dissolves rapidly in the Ceylon oil with a considerable increase of heat, and a slight expulsive movement, a tough extract-like substance remaining behind. With the Chinese oil the reaction is *slow*, the development of heat but *very slight*, quiet, and the residue a *soft or liquid* substance.

Chromate of potash decomposes partially the Ceylon oil into brown flakes, which are suspended in the solution. This is *deprived of its yellow colour*, whilst the undecomposed portion of the oil assumes a yellowish light red colour, and becomes thick. The solution treated with Chinese oil does not *entirely lose its yellow colour*, contains *no flakes*, and the oil, turbid, emulsive-like, does not become clear again.

Sulphuric acid also furnishes a good test for these oils; the Ceylon oil forms with it a *solid hard mass*, changing from a brownish-green into deep black; in the Chinese oil, this substance is softer, and *deep olive green*. A smaller quantity of acid colours the oils *purple-red*, whilst *muratic acid* imparts to them a violet colour.

4. *Ol. Sassafras (Sassafras)*. This oil is distinguished from most other oils by the clear solution produced by iodine *without inspissation*. The green colour, which is at first produced by two parts of oil and one part sulphuric acid, is *not produced by any other oil*; by heat, this colour changes to *blood-red*. A greater quantity of oil produces in the heated acid a magnificent amaranth red colour, whilst the oil itself appears only brownish or bluish red. With *nitric acid* the decomposition takes place *without heat*, and reddish brown resin is formed, which on being heated becomes hard and brittle. The great specific gravity and the low degree of solubility in alcohol will easily lead to the detection of an admixture of the latter which would counteract these properties.

5. *Ol. Anisi Stellati (Star Anise)*. This oil participates in many properties of those oils of the umbelliferae which contain much stearoptene. Its combination with iodine, which takes place with a less development of vapour and heat, congeals into a *solid resinous substance*. By *sulphuric acid* this oil also easily becomes inspissated, is changed into a *solid mass*, and becomes by heat dark *blood-red*. *Nitric acid*, however, produces only a thick fluid balsam, whilst the oil becomes yellow, and by heat reddish-brown. The difficulty with which the oil is dissolved in five or six parts of alcohol, and in the alcoholic solution of potash, with slight coloration, as also its relation to cold, are useful tests.

6. *Ol. Anisi vulgaris (common Anise)*. The constant specific gravity of the *ol. anisi* (from 0.97 to 0.99, and still more frequently from 0.98 to 0.99), as well as its disposition to congeal readily at below a medium temperature, are good tests for this oil. But still more so is its *quick* congelation into a *solid hard mass* with iodine, accompanied with a perceptible increase of heat, and the development of yellowish-red and gray vapours. *Sulphuric acid* heated with the oil, produces a beautiful purple-red colour, and quickly inspissates and hardens it. The other reactions are similar to those of oil of star anise, and will, combined with those here mentioned, sufficiently characterize this oil.

7. *Ol. Ruta (Rue)*. The high price and strong smell of this oil lead to and facilitate its adulteration. If prepared in the laboratory, this oil is distinguished by being slowly dissolved by iodine, *unaccompanied by any external signs of reaction*, and the formation of *slightly viscid liquid*; by this means, adulterations with oils of coniferae, aurantiaceae, and most labiateae can be detected in it. Nitric acid acts but slowly on it, and changes it into a greenish yellow thin liquid balsam; chromate of potash produces no reaction. By the *turbid solution in alcohol*, by the reddish brown solution in liquor potassae, and by the similar but darker coloration which the oil and the acid assume by *sulphuric acid*, the cheaper oils of the labiateae may be easily detected in it. The commercial compared with these characteristics appeared to be only an adulterated one.

8. *Ol. Cajeputi (Cajeput)*. Omitting the tests for less frequently occurring adulterations of this oil, I confine myself to mentioning only those tests of its purity which are the result of my experiments, chiefly with regard to the *rectified oil*, which alone ought to be employed for medical purposes.

The first of these is the nature of the residue, resulting from the reaction of iodine after a slightly energetic reciprocal action, during which the temperature was but little increased, and the development of yellowish-red vapours but slight (in another crude oil no such development took place), the residue becomes immediately inspissated into a *loose coagulum*, which is soon changed into a dry greenish-brown brittle mass. Fulminating oils are therefore easily detected, also the more energetically acting oils of the labiateae; viz. *ol. lavendul. spiraeae origani*. But also the less violently acting oils of labiateae, such as *ol. rorismarini*, which serves most frequently for adulteration, but which are distinguished by the energetic action of a solution of iodine, can be recognised by the degree of energy with which this reaction takes place; all, however, would materially alter the nature of the residue of the iodine test above described. The *ol. rorismarini* manifests under certain circumstances, also, some congeulating solid parts in its residue, but which always has the consistency of a soft extract.

The slight changes of colour which are produced by chromate of potash, are some-

what more marked with the ol. rorismarini, but the equally slight colour of the solution in liquor potassæ, which is clear in the cold and turbid when warm, is the same in the ol. rorismarini. The latter oil could not be detected by the *sulphuric acid* test; the latter assumes a deep red yellowish colour, and the oil becomes brownish; by this, however, many other adulterations may be indicated. The weak colorations of the ol. cajeputi by *nitric acid*, which imparts only a reddish and brownish colour, accompanied by a violent reaction and formation of a liquid balsam, will easily distinguish it from some other oils, but not from ol. rorismarini. Its relation to iodine is, therefore, the safest test; it can also be recognized by a sensation of cold which it leaves behind in the mouth. Its specific gravity being below 0.91 to 0.92, will show the presence of lighter oils and alcohol, and a divided rectification, and its relation to water will detect the adulteration with camphor.

9. *Ol. Mentha Piperita (Peppermint)*.—Any adulteration of this oil, except with alcohol or other mint oils, could be easily detected by the peculiar smell and taste of this oil. The presence of alcohol is betrayed by the specific gravity, which is seldom under 0.90, and which must be considerably lower if the alcohol be stronger. Of the other mint oils we certainly are only acquainted with that of *M. crispata* and *crispata*; we may, however, conclude from the deviating relation of the ol. menth. piperit. to *chromate of potash* and to *iodine*, that the other sorts differ from it chemically, as well as the plants from which they are obtained differ from one another in smell.

The most distinguishing character, which the peppermint oil shares with *no other oil of the labiata*, though with some of the composite, is its relation to *chromate of potash*, which communicates to it a *deep red brown colour*, and inspissates it into a coagulum more like an extract than a resin, and by motion is divided into a flaky form, whilst the solution of the salt *soon loses the whole of its yellow colour*, or appears yellowish-green.

The purple red colour imparted to the oil by the fourth part of its volume of *nitric acid*, is, at least for the qualities of 0.89 to 0.90, very characteristic. The other oils, which become merely brown, show at least a tendency to red, but all, upon an addition of acid at a higher temperature, change to a reddish-brown, and into a liquid balsam.

Mr. B. Sandrock of Hamburg, states that American oil of peppermint is adulterated with oil of turpentine, which appears to be the product of some other species of pinus than ours. He has frequently rectified quantities of from 80 to 100 lbs. of the American oil, in which the smell of oil of turpentine was distinctly perceived; but not to such a degree as would be the case if common oil of turpentine had been employed.

Several samples of English oil of peppermint were found by the author to be mixed with this American oil of peppermint, the price of which is only five or six marks per pound. Bley has also perceived this smell of turpentine in the oil of peppermint. The smell, however, is no certain criterion in this case, and the adulteration is better discovered by the relation to iodine and alcohol, and by the specific gravity. Pure English oil of peppermint has a specific gravity of 0.910 to 0.920; it does not explode with iodine, but forms with it a homogeneous mass, and is soluble in its own weight of alcohol.

The American oil, in which a great proportion of oil of turpentine is supposed to be contained, is sold by the name of *crude oil*, in tin bottles of twenty pounds. It is of a yellowish colour, very resinous, often as thick as oil of bitter almonds, and has a strong accessory odour of oil of turpentine. Its specific gravity is 0.855 to 0.859. When distilled with water, half of it passes over with equal parts of water, then the proportion of the water increases, and with the last yellow, somewhat thicker parts of the oil are distilled over, but with difficulty. About five-sixths of the crude oil are obtained perfectly clear like water. The first half of the rectified oil has a specific weight of 0.844, which increases, so that the latter portions have a specific gravity of 0.875 to 0.880. The oil retains now, as before, the smell and taste of turpentine, is only dissolved in five or six parts of alcohol, and explodes strongly with iodine. The resin which remains after the distillation amounts to about four or five per cent. of the oil, is soft, yellowish, turbid, and strongly smells of the oil. Heated for some time at a slight temperature, it changes these properties for all those of the pine resin.

10. *Ol. Thymi (Thyme)*. This oil is distinguished by no peculiarity, and, in most cases where it is employed as perfume or externally, its pure and fine smell will be a sufficient criterion. By its slight reaction upon *iodine*, the adulteration with turpentine-oil might be detected, whilst its stronger reaction upon *chromate of potash* would serve to detect other admixtures.

11. *Ol. Lavandule (Lavender)*. This delicate oil suffers no other admixture but that of alcohol without becoming worthless, and in the inferior cheap qualities which are sold, the presence of alcohol is discoverable by the specific gravity. Of seventeen samples examined, the lowest specific gravity of the inferior oil was 0.86; that of the best

qualities, mostly 0·87 to 0·89. The peculiar character of the lavender oil by which it is distinguished, with regard to the degree, from all oils obtained from the *labiate*, is its quick and violent fulmination with iodine, and the entirely changed, pungent, acidobalsamic smell of the soft, extract-like residue. This character is invariably observed in all genuine oils, both commercial, and those prepared in the laboratory. The inferior, cheaper commercial sort, does not fulminate. An intentional addition of one-third of alcohol did not perceptibly weaken the fulmination; also, one half of alcohol did not destroy, but only weaken it: an equal volume of alcohol being added to the oil no fulmination took place, but a lively ebullition and development of yellowish-red vapours. A moderate proportion of alcohol cannot, therefore, be discovered by these reactions; for this purpose the almost indifferent relation of the pure oil to santaline is a safer guide, as that containing alcohol dissolves the latter readily and quickly. An adulteration with fulminating oils, which in this case cannot be detected by iodine, would be discovered by the differing relation to caustic potash. The alcoholic solution of the latter forms a clear solution with lavender oil, to which it communicates a dark yellowish-red brown colour, whilst the other oils are dissolved in it with difficulty, and become turbid, with but a slight coloration. Among the better tests, we may also reckon the deep reddish-brown colour produced by sulphuric acid accompanied by a strong inspissation, whilst the equally coloured acid has a slight shade of yellow.

12. *Ol. Cubebarium (Cubeba)*. This oil, which is devoid of oxygen, differs from others having a similar composition by its viscosity and weak action upon iodine, which imparts to it at the beginning of the reciprocal reaction a violet colour. Even absolute alcohol in large proportions, and at a high temperature, forms a solution which is mostly clear; equal weights produce a very turbid solution, throwing down flakes. The oil, which is strongly clouded by nitric acid, becomes by heat only pale red, but is decomposed and converted into consistent resin. Sulphuric acid assumes a red colour, the oil becoming crimson. These characteristics will suffice for this oil, which is already difficult to be adulterated on account of its viscosity and want of colour.

13. *Ol. Bergamotte, (Bergamot)*. The oils of the aurantiaceæ are in a still higher degree than the lavender oil protected by their delicate odour from adulteration, except with alcohol; on the other hand, a mixture of these oils with one another is easier effected, and detected with greater difficulty. There might, however, be but little inducement for doing this, except in the case of *ol. flor. aurant.*, which is proportionately much dearer than the others. The similarity of the respective chemical properties admits also here of no better test than the smell. The unvarying and great sp. gr. (from 0·87 to 0·88) will serve to detect any admixture of alcohol. The relation which the bergamot oil has to this solvent, shows distinctly the difference which exists between its own proportion of oxygen and that of the other oils of the same family; it is readily dissolved in alcohol, but, like the other oils, it makes, at least when fresh, the solution opaque. It is also distinguished from the lemon and orange oils, by being easily and clearly dissolved in *liquor potassa*. This difference in its elements also is manifested in the reaction upon iodine, not so much with regard to its fulminating property, which, although weaker than in the lemon oil, is rather stronger than in the orange oil, but by the homogeneous nature of the residue, which, in the two last mentioned oils, and in all oils free of oxygen, consists of two combinations, differing in consistency. By the incapacity of dissolving santaline, this oil is, as well as the others of the same family, protected against an admixture of alcohol. One part of alcohol added to five parts of the oil is hardly able to impair the fulmination; two drops of alcohol added to three drops of oil produce certainly no real fulmination, but still a lively reciprocal action with effervescence.

14. *Ol. Copaiva (Copaiva)*. Small proportions of turpentine-oil cannot easily be detected in this oil, as both react in most cases in the same manner. A chief distinction is the weaker fulmination of the *ol. copaiv.*, as also the circumstance that the latter requires double the quantity of alcohol for its solution, which, notwithstanding, still remains turbid. Also its relation to sulphuric acid is somewhat different; the latter becomes yellowish brown red, but turpentine-oil lively yellowish-red.

OIL OF VITRIOL, is the old name of concentrated SULPHURIC ACID.

OLEATES, are saline compounds of oleic acid with the bases.

OLEFIANT GAS, is the name originally given to bi-carburetted hydrogen.

OLEIC ACID, is the acid produced by saponifying olive-oil, and then separating the base by dilute sulphuric or muriatic acid. See FATS, and STEARINE.

This acid is a large product in the manufacture of stearic acid, and has hitherto been of inferior value, as it burned very ill in lamps; but it has been found to be capable of improvement by agitation with dilute sulphuric acid, and in that state susceptible of affording a good light when the burner-tube of the lamp is kept cool by enclosing it in a perforated small plate, which prevents the flame from heating the said

burner small pipe, in which the wick is supported. Messrs. Humfrey and Wilson have patented it.

OLEINE, is the thin oily part of fats, naturally associated in them with glycerine, margarine, and stearine.

OLIBANUM, is a gum-resin, used only as incense in Roman-catholic churches.

OLIVE OIL. See **OILS**, **UNCTUOUS**.

ONYX, an ornamental stone of little value; a subspecies of quartz.

OOLITE, is a species of limestone composed of globules clustered together, commonly without any visible cement or base. These vary in size from that of small pin-heads to peas; they sometimes occur in concentric layers, at others they are compact, or radiated from the centre to the circumference; in which case, the oolite is called *roogenstein* by the German mineralogists. In geology the oolitic series includes all the strata between the iron sand above and the red marl below. It is the great repository of the best architectural materials which the midland and eastern parts of England produce; it is divided into three systems:—

1. *The upper oolite*, including the argillo-calcareous Purbeck strata, which separate the iron and oolitic series; the oolitic strata of Portland, Tisbury, and Aylesbury; the calcareous sand and concretions, as of Shotover and Thame; and the argillo-calcareous formation of Kimmeridge, the oak tree of Smith.

2. *The middle oolite*; the oolitic strata associated with the coral rag; calcareous sand and grit; great Oxford clay, between the oolites of this and the following system.

3. *The lower oolite*; which contains numerous oolitic strata, occasionally subdivided by thin argillaceous beds; including the cornbrash, forest marble, schistose oolite, and sand of Stonesfield and Hinton, great oolite and inferior oolite; calcareo-siliceous sand passing into the inferior oolite; great argillo-calcareous formation of lias, and lias marl, constituting the base of the whole series.

These formations occupy a zone 30 miles broad in England.

OOST, or **OAST**; the trivial or provincial name of the stove in which the picked hops are dried.

OPAL; an ornamental stone of moderate value. See **LAPIDARY**.

OPERAMETER, is the name given to an apparatus patented in February, 1829, by Samuel Walker, cloth manufacturer, in the parish of Leeds. It consists of a train of toothed wheels and pinions enclosed in a box, having indexes attached to the central arbor, like the hands of a clock, and a dial plate; whereby the number of rotations of a shaft projecting from the posterior part of the box is shown. If this shaft be connected by any convenient means to the working parts of a gig mill, shearing frame, or any other machinery of that kind for dressing cloths, the number of rotations made by the operating machine will be exhibited by the indexes upon the dial plate of this apparatus. In dressing cloths, it is often found that too little or too much work has been expended upon them, in consequence of the unskilfulness or inattention of the workmen. By the use of the operameter, that evil will be avoided, as the master may regulate and prescribe beforehand by the dial the number of turns which the wheels should perform.

A similar clock-work mechanism, called a *counter*, has been for a great many years employed in the cotton factories to indicate the number of revolutions of the main shaft of the mill, and of course the quantity of yarn that might or should be spun, or of cloth that might be woven in the power looms. A common pendulum or spring clock is commonly set up alongside of the counter; and sometimes the indexes of both are regulated to go together, when the mill performs its average work.

OPIUM, is the juice which exudes from incisions made in the heads of ripe poppies, (*papaver somniferum*), rendered concrete by exposure to the air and the sun. The best opium which is found in the European markets comes from Asia Minor and Egypt; what is imported from India is reckoned inferior in quality. This is the most valuable of all the vegetable products of the gum-resin family, and very remarkable for the complexity of its chemical composition. Though examined by many able analysts, it still requires further elucidation.

Opium occurs in brown lumps of a rounded form, about the size of the fist, and often larger; having their surface covered with the seeds and leaves of a species of *rumex*, for the purpose of preventing the mutual adhesion of the pieces in their semi-indurated state. These seeds are sometimes introduced into the interior of the masses to increase their weight; a fraud easily detected by cutting them across. Good opium is hard in the cold, but becomes flexible and doughy when it is worked between the hot hands. It has a characteristic smell, which by heat becomes stronger, and very offensive to the nostrils of many persons. It has a very bitter taste. Water first softens, and then reduces it to a pasty magma. Proof spirit digested upon opium forms *laudansum*, being a better solution of its active parts than can be obtained by either water or strong alcohol alone. Water distilled from it acquires its peculiar smell, but carries over no volatile oil.

Opium was analyzed by Bucholz and Braconnot, but at a period anterior to the knowledge of the alkaline properties of morphia and opian (narcotine). Bucholz found in 100 parts of it, 9.0 of resin; 30.4 of gum; 35.6 of extractive matter; 4.8 of caoutchouc; 11.4 of gluten; 2.0 of ligneous matter, as seeds, leaves, &c.; 6.8 of water and loss. John, who made his analysis more recently, obtained 2.0 parts of a rancid nauseous fat; 12.0 of a brown hard resin; 10.0 of a soft resin; 2 of an elastic substance; 12.0 of morphia and opian; 1.0 of a balsamic extract; 25.0 of extractive matter; 2.5 of the meconates of lime and magnesia; 18.5 of the epidermis of the heads of the poppy; 15 of water, salts, and odorous matter.

In the Numbers of the Quarterly Journal of Science for January and June, 1830, I published two papers upon opium and its tests, containing the results of researches made upon some porter which had been fatally dosed with that drug: for which crime, a man and his wife had been capitally punished, about a year before, in Scotland.* From the first of these papers the following extract is made:—

“Did the anodyne and soporific virtue of opium reside in one definite principle, chemical analysis might furnish a certain criterion of its powers. It has been pretty generally supposed that this desideratum is supplied by Sertürner’s discovery of morphia. Of this narcotic alkali not more than 7 parts can be extracted by the most rigid analysis from 100 of the best Turkey opium; a quantity, indeed, somewhat above the average result of many skilful chemists. Were morphia the real medicinal essence of the poppy, it should display, when administered in its active saline state of acetate, an operation on the living system commensurate in energy with the fourteen-fold concentration which the opium has undergone. But so far as may be judged from the most authentic recent trials, morphia in the acetate seems to be little, if any, stronger as a narcotic than the heterogeneous drug from which it has been eliminated. Mr. John Murray’s experiments would, in fact, prove it to be greatly weaker; for he gave $\frac{z}{2}$ drachms of superacetate of morphia to a cat, without causing any poisonous disorder. This is perhaps an extreme case, and may seem to indicate either some defect in the preparation, or an uncommon tenacity of life in the animal. To the same effect Lassaigue found that a dog lived 12 hours after 36 grains of acetate of morphia in watery solution had been injected into its jugular vein. The morphia meanwhile was entirely decomposed by the vital forces, for none of it could be detected in the blood drawn from the animal at the end of that period. Now, from the effects produced by 5 grains of watery extract of opium, injected by Orfila into the veins of a dog, we may conclude that a quantity of it, equivalent to the above dose of the acetate of morphia, would have proved speedily fatal.

“Neither can we ascribe the energy of opium to the white crystalline substance called *narcotine*, or *opian*, extracted from it by the solvent agency of sulphuric ether; for Orfila assures us that these crystals may be swallowed in various forms by man, even to the amount of 2 drachms in the course of 12 hours, with impunity; and that a drachm of it dissolved in muriatic or nitric acid may be administered in the food of a dog without producing any inconvenience to the animal. It appears, however, on the same authority that 30 grains of it dissolved in acetic or sulphuric acid caused dogs that had swallowed the dose to die under convulsions in the space of 24 hours, while the head was thrown backwards on the spine. Oil seems to be the most potent menstruum of narcotine; for 3 grains dissolved in oil readily kill a dog, whether the dose be introduced into the stomach, or into the jugular vein.

“Since a bland oil thus seems to develop the peculiar force of narcotine, and since opium affords to ether, and also to ammonia, an unctuous or fatty matter, and a resin (the caoutchouc of Bucholz) to absolute alcohol, we are entitled to infer that the activity of opium is due to its state of composition, to the union of an oleate or margarate of narcotine with morphia. The meconic acid associated with this salifiable base has no narcotic power by itself, but may probably promote the activity of the morphia.”

Opian or narcotine, and morphia, may be well prepared by the following process. The watery infusion of opium being evaporated to the consistence of an extract, every 3 parts are to be diluted with one and a half parts in bulk of water, and then mixed in a retort with 20 parts of ether. As soon as five parts of the ether have been distilled over, the narcotic salt contained in the extract will be dissolved. The fluid contents of the retort are to be poured hot into a vessel apart, and the residuum being washed with 5 other parts of ether, they are to be added to the former. Crystals of narcotine will be obtained as the solution cools. The remaining extract is to be diluted in the retort with a little water, and the mixture set aside in a cool place. After some time, some narcotine will be found crystallized at the bottom. The supernatant liquid thus freed from narcotine being decanted off, is to be treated with caustic ammonia; and

* A country merchant travelling in a steam-boat upon the river Clyde, who had incautiously displayed a good deal of money, was poisoned with porter charged with laudanum. The contents of the dead man’s stomach were sent to me for analysis.

the precipitate thrown upon a filter. This, when well washed and dried, is to be boiled with a quantity of spirit of wine at 0·84, equal to thrice the weight of the opium employed, containing 6 parts of animal charcoal for every hundred parts of the drug. The alcoholic solution being filtered hot, affords, on cooling, colourless crystals of morphia.

This alkali may be obtained by a more direct process, without alcohol or ether. A solution of opium in vinegar is to be precipitated by ammonia; the washed precipitate is to be dissolved in dilute muriatic acid, the solution is to be boiled along with powdered bone black, filtered, and then precipitated by ammonia. This, when washed upon a filter and dried, is white morphia, which may be dissolved in hot alcohol, if fine crystals be wanted. See MORPHIA.

Analysis of Opium. — Half an ounce of the opium to be examined is cut into small pieces and bruised in a mortar with spirit of alcohol at 71°; the fluid is then expressed through linen, and the refuse washed with from 10 to 12 drachms of the same alcohol; the alcoholic solution is then to be filtered into a glass containing one drachm of spirits of ammonia. In 12 hours' time all the morphia, with some narcotine and meconate of ammonia, will have become deposited. The separation of the gritty crystals of morphia, which adhere to the sides of the vessel from the light, pointed crystals of narcotine, which for the most part float in the fluid, is to be effected by decantation, according to Guillermond, but this plan does not leave the morphia free from narcotine. In order effectually to separate the narcotine, the adhering meconate of ammonia must be removed by washing in water, and then shaking the crystals in pure ether, or better still in chloroform, by which the narcotine is readily dissolved, while the morphia remains entirely insoluble. After this treatment the morphia is left behind in rather large gritty crystals, slightly discoloured. This process may be varied by employing boiling alcohol and powdered opium, and adding the solution, still hot, to the solution of ammonia. According to Guillermond, 15 grammes of opium should yield at least 1·25 grammes or 8·33 per cent. Reich estimates 10 per cent., and others 12 per cent. The author gives the percentage of morphia which is obtained by the various processes of different experimenters, and states that the largest proportion (13·50 per cent.) is procured by the modification of Guillermond's method, now described, which he also considers the simplest and most certain for ascertaining the proportion of morphia.

The following process is recommended by Dr. Rieget for the detection of small quantities of opium. To the suspected substance, some potash is to be added, and then it is shaken with ether. A strip of white blotting paper is to be moistened with the solution, several times repeated. When dry, the paper is then to be moistened with muriatic acid, and exposed to the steam of hot water; if opium be present, the paper will be more or less coloured red.

Imported, in 1850, 126,102 lbs., in 1851, 106,113 lbs.; retained for consumption, 1850, 42,324 lbs., 1851, 50,368 lbs.; exported, 1850, 87,451 lbs., 1851, 65,640 lbs.; duty received, 1850, 2,222*l.*, 1851, 2,645*l.*

OPOBALSAM, is the balsam of Peru in a dry state.

OPOPONAX, is a gum-resin resembling gum ammoniac. It is occasionally used in medicine.

ORANGE DYE, is given by a mixture of red or yellow dyes in various proportions. Annatto alone dyes orange; but it is a fugitive colour.

ORCINE, is the name of the colouring principle of the *lichen dealbatus*. The lichen dried and pulverized is to be exhausted by boiling alcohol. The solution filtered hot, lets fall in the cooling, crystalline flocks, which do not belong to the colouring matter. The supernatant alcohol is to be distilled off, the residuum is to be evaporated to the consistence of an extract, and triturated with water till this liquid will dissolve no more. The aqueous solution reduced to the consistence of syrup, and left to itself in a cool place, lets fall, at the end of a few days, long brown brittle needles, which are to be freed by pressure from the mother water, and dried. That water being treated with animal charcoal, filtered and evaporated, will yield a second crop of crystals. These are orcine. Its taste is sweet and nauseous; it melts readily in a retort into a transparent liquid, and distils without undergoing any change. It is soluble in water and alcohol. Nitric acid colours it blood-red; which colour afterwards disappears. Subacetate of lead precipitates it completely. Its conversion into the archil red is effected by the action of an alkali, in contact with the air. When dissolved, for example, in ammonia, and exposed to the atmosphere, it takes a dirty brown red hue; but when the orcine is exposed to air charged with vapours of ammonia, it assumes by degrees a fine violet colour. To obtain this result, the orcine in powder should be placed in a capsule, alongside of a saucer containing water of ammonia; and both should be covered by a large bell glass; whenever the orcine has required a dark brown cast, it must be withdrawn from under the bell, and the excess of ammonia be allowed to volatilize. As soon as the smell of ammonia is gone, the orcine is to be dis-

solved in water; and then a few drops of ammonia being poured into the brownish liquid, it assumes a magnificent reddish-violet colour. Acetic acid precipitates the red lake of lichen.

ORES (*Mines*, Fr.; *Erze*, Germ.); are the mineral bodies which contain so much metal as to be worth the smelting, or being reduced by fire to the metallic state. The substances naturally combined with metals, which mask their metallic characters, are chiefly oxygen, chlorine, sulphur, phosphorus, selenium, arsenic, water, and several acids, of which the carbonic is the most common. Some metals, as gold, silver, platinum, often occur in the metallic state, either alone, or combined with other metals, constituting what are called native alloys.

I have described in the article **MINE**, the general structure of the great metallic repositories within the earth, as well as the most approved methods of bringing them to the surface; and in the article **METALLURGY**, the various mechanical and chemical operations requisite to reduce the ores into pure metals. Under each particular metal, moreover, in its alphabetical place, will be found a systematic account of its most important ores.

Relatively to the theory of the smelting of ores, the following observations may be made. It is probable that the coaly matter employed in that process is not the *immediate agent* of their reduction; but the charcoal seems first of all to be transformed by the atmospherical oxygen into the oxide of carbon: which gaseous product then surrounds and penetrates the interior substance of the oxides, with the effect of decomposing them, and carrying off their oxygen. That this is the true mode of action is evident from the well-known facts, that bars of iron, stratified with pounded charcoal, in the steel cementation-*chest*, most readily absorb the carbonaceous principle to their innermost centre, while their surfaces get blistered by the expansion of carburetted gases formed within; and that an intermixture of ores and charcoal is not always necessary to reduction, but merely an interstratification of the two, without intimate contact of the particles. In this case, the carbonic acid which is generated at the lower surfaces of contact of the strata, rising up through the first bed of ignited charcoal, becomes converted into carbonic oxide; and this gaseous matter, passing up through the next layer of ore, seizes its oxygen, reduces it to metal, and is itself thereby transformed once more into carbonic acid; and so on in continual alternation. It may be laid down, however, as a general rule, that the reduction is the more rapid and complete, the more intimate the mixture of the charcoal and the metallic oxide has been, because the formation of both the carbonic acid and carbonic oxide becomes thereby more easy and direct. Indeed the cementation of iron bars into steel will not succeed, unless the charcoal be so porous as to contain, interspersed, enough of air to favour the commencement of its conversion into the gaseous oxide; thus acting like a ferment in brewing. Hence also finely pulverized charcoal does not answer well; unless a quantity of ground iron cinder or oxide of manganese be blended with it, to afford enough of oxygen to begin the generation of carbonic oxide gas; whereby the successive transformations into acid and oxide are put in train.

OR-MOLU. The *or-molu* of the brass founder, popularly known as an imitation of red gold, is extensively used by the French workmen in metals. It is generally found in combination with grate and stove work. It is composed of a greater proportion of copper and less zinc than ordinary brass, is cleaned readily by means of acid, and is burnished with facility. To give this material the rich appearance it is not unfrequently brightened up after "dipping" (that is cleaning in acid) by means of a scratch brush (a brush made of fine brass wire), the action of which helps to produce a very brilliant gold-like surface. It is protected from tarnish by the application of lacquer.

ORNAMENTAL BRASS CASTINGS. Brass castings are produced in sand, by means of patterns. The making of these patterns or models is a work involving no small amount of skill and knowledge; the simpler kinds are made by the ordinary workman; but in cases where figures, foliage, or animals are introduced, the eye and the hand of the artist become necessary. The object is first designed, then modelled in wax; a cast in lead is formed; it is then cast in brass and chased; this forms the pattern or model for the *caster*.

Ordinary globular or simple forms are readily copied; but when the human figure, animals, or foliage is introduced, the difficulty is increased. The castings can only be effected by means of false *cores*, viz., hanging pieces of sand which are made up and lifted out in solid portions, before the model can be removed, and which afterwards are again introduced. An ordinary plaster cast with the seams upon it, if examined, will best explain the meaning of every square inch or compartment marked thereon, and shows when a core has been in a metal casting. To put the sand in a condition to produce a finer impression, powdered charcoal is dusted upon it, the cores being introduced, the moulds closed having been previously dried, and runners made for the introduction of

the metal (which is usually melted in earthen or clay crucibles, and in an air furnace, the fuel used being coke), follow and complete the operation.

ORPIMENT (Eng. and Fr., *Yellow sulphuret of arsenic*; *Operment*, *Rauschgelb*, Germ.); occurs in indistinct crystalline particles, and sometimes in oblique rhomboidal prisms; but for the most part, in kidney and other imitative forms; it has a scaly and granular aspect; texture foliated, or radiated; fracture small, granular, passing into conchoidal; spintery, opaque, shining, with a weak diamond lustre; lemon, orange, or honey yellow; sometimes green; specific gravity, 3.44 to 3.6. It is found in floetz rocks, in marl, clay, sand-stone, along with realgar, lead-glance, pyrites, and blende, in many parts of the world. It volatilizes at the blowpipe. It is used as a pigment.

The finest specimens come from Persia, in brilliant yellow masses, of a lamellar texture, called golden orpiment.

Artificial orpiment is manufactured chiefly in Saxony, by subliming in cast-iron cucurbits, surmounted by conical cast-iron capitals, a mixture in due proportions of sulphur and arsenious acid (white arsenic). As thus obtained, it is in yellow compact opaque masses, of a glassy aspect; affording a powder of a pale yellow colour. Genuine orpiment is often adulterated with an ill-made compound, which is sold in this country by the preposterous name of king's yellow. This fictitious substance is frequently nothing else than white arsenic combined with a little sulphur; and is quite soluble in water. It is therefore a deadly poison, and has been administered with criminal intentions and fatal effects. I had occasion, some years ago, to examine such a specimen of king's yellow, with which a woman had killed her child. A proper insoluble sulphuret of arsenic, like the native or the Saxon, may be prepared by transmitting sulphuretted hydrogen gas through any arsenical solution. It consists of 98.09 sulphur, and 60.92 of metallic arsenic, and is not remarkably poisonous. The finest kinds of native orpiment are reserved for artists; the inferior are used for the indigo vat. They are all soluble in alkaline lyes, and in water of ammonia.

ORYCTNOGOSY, is the name given by Werner to the knowledge of minerals; and is therefore synonymous with the English term Mineralogy.

OSTEOCOLLA, is the glue obtained from bones, by removing the earthy phosphates with muriatic acid, and dissolving the cartilaginous residuum in water at a temperature considerably above the boiling point, by means of a digester. It is a very indifferent article.

OSMIUM, is a metal discovered by Mr. Tennant in 1803, among the grains of native platinum. It occurs also associated with the ore of iridium. As it has not been applied to any use in the arts, I shall reserve any chemical observations that the subject may require for the article **PLATINUM**.

OTTO OF ROSES.—*Means of determining the purity of the Otto of Roses*.—*Sulphuric acid test*.—One or two drops of the oil to be tested is put into a watch-glass; the same number of drops of very concentrated sulphuric acid are added, and the two fluids mixed with a glass rod. All the oils are rendered more or less brown by this proceeding; but the otto of roses retains the purity of its odour. The oil of geranium acquires a strong and disagreeable odour, which is perfectly characteristic.

OXALATES, are saline compounds of the bases with

OXALIC ACID (*Acid oxalique*, Fr.; *Sauerkleeaure*, Germ.); which is the object of a considerable chemical manufacture. It is usually prepared upon the small scale by digesting four parts of nitric acid of specific gravity 1.4, upon one part of sugar, in a glass retort; but on the large scale, in a series of salt-glazed stoneware pipkins, two-thirds filled, and set in a water bath. The addition of a little sulphuric acid has been found to increase the product. 15 pounds of sugar yield fully 17 pounds of the crystalline acid. This acid exists in the juice of wood sorrel, the *oxalis acetosella*, in the state of a binoxalate; from which the salt is extracted as an object of commerce in Switzerland, and sold under the name of salt of sorrel, or sometimes, most incorrectly, under that of salt of lemons.

Some prefer to make oxalic acid by acting upon 4 parts of sugar, with 24 parts of nitric acid, of specific gravity 1.220, heating the solution in a retort till the acid begins to decompose, and keeping it at this temperature as long as nitrous gas is disengaged. The sugar loses a portion of its carbon, which combining with the oxygen of the nitric acid, becomes carbonic acid, and escapes along with the deutoxide of nitrogen. The remaining carbon and hydrogen of the sugar being oxidized at the expense of the nitric acid generate a mixture of two acids, the oxalic and the malic. Whenever gas ceases to issue, the retort must be removed from the source of heat, and set aside to cool; the oxalic acid crystallizes, but the malic remains dissolved. After draining these crystals upon a filter funnel, if the brownish liquid be further evaporated, it will furnish another crop of them. The residuary mother water is generally regarded as malic acid, but it also contains both oxalic and nitric acids; and if heated with 6 parts of the latter acid, it will yield a good deal more oxalic acid at the expense of the malic. The brown crystals

now formed being, however, penetrated with nitric as well as malic acid, must be allowed to dry and effloresce in warm dry air, whereby the nitric acid will be got rid of without injury to the oxalic. A second crystallization and efflorescence will entirely dissipate the remainder of the nitric acid, so as to afford pure oxalic acid at the third crystallization. Sugar affords, with nitric acid, a purer oxalic acid, but in smaller quantity, than saw-dust, glue, silk, hairs, and several other animal and vegetable substances.

Oxalic acid occurs in aggregated prisms when it crystallizes rapidly, but in tables of greater or less thickness when slowly formed. They lose their water of crystallization in the open air, fall into powder, and weigh 0.28 less than before; but still retain 0.14 parts of water, which the acid does not part with except in favour of another oxide, as when it is combined with oxide of lead. The effloresced acid contains 20 per cent. of water, according to Berzelius. By my analysis, the crystals consist of three prime equivalents of water = 27, combined with one of dry oxalic acid = 36; or in 100 parts, of 42.86 of water with 57.14 of acid. The acid itself consists of 2 atoms of carbon = 12, + 3 of oxygen = 24; of which the sum is, as above stated, 36. This acid has a sharp sour taste, and sets the teeth on edge; half a pint of water, containing only 1 gr. of acid, very sensibly reddens litmus paper. Nine parts of water dissolve one part of the crystals at 60° Fahr. and form a solution of spec. grav. 1.045, which when swallowed acts as a deadly poison. Alcohol also dissolves this acid. It differs from all the other acid products of the vegetable kingdom, in containing no hydrogen, as I demonstrated (in my paper upon the ultimate analysis of organic bodies, published in the Phil. Trans. for 1822), by its giving out no muriatic acid gas, when heated in a glass tube with calomel or corrosive sublimate.

Oxalic acid is employed chiefly for certain styles of discharge in calico-printing, (which see), and for whitening the leather of boot-tops. Oxalate of ammonia is an excellent reagent for detecting lime and its salts in any solution. The acid itself, or the bi-oxalate of potash, is often used for removing ink or iron-mould stains from linen.

A convenient plan of testing the value of peroxide of manganese for bleachers, &c., originally proposed by Berthier, has been since simplified by Dr. Thomson, as follows. In a poised Florence flask weigh 600 grains of water, and 75 grains of crystallized oxalic acid; add 50 grains of the manganese, and as quickly as possible afterwards from 150 to 200 grains of concentrated sulphuric acid. Cover the mouth of the flask with paper, and leave it at rest for 24 hours. The loss of weight it has now suffered corresponds exactly to the weight of peroxide of manganese present; because the quantity of carbonic acid producible by the reaction of the oxalic acid with the peroxide is precisely equal to the weight of the peroxide, as the doctrine of chemical equivalents shows.

By exposing 100 parts by weight of dry sugar to the action of 825 parts of hot nitric acid of 1.38 specific gravity, evaporating the solution down to one-sixth of its bulk, and setting it aside to crystallize, from 58 to 60 parts of beautiful crystals of oxalic acid may be obtained, according to Schlesinger.

Oxalic acid may be produced by the action of nitric acid upon most vegetable substances, and especially from those which contain no nitrogen, such as well-washed saw-dust, starch, gum, and sugar. The latter is the article generally employed, and possesses many advantages over every other material. Treacle, which is a modification of sugar, also comes within the same ranges. A very contemptible spirit of exaggeration prevails in respect to the amount of produce attainable by oxalic acid makers from a given weight of sugar. The generality of the statements is absurdly false. One cwt. of good treacle will yield about 116 lbs. of marketable oxalic acid, and the same weight of good brown sugar may be calculated to produce about 140 lbs. of acid. As a general rule, 5 cwts. of saltpetre, or an equivalent of nitrate of soda, with 24 cwts. of sulphuric acid, will generate sufficient nitric acid to decompose 1 cwt. of good sugar, and yield, as above, 140 lbs. of fair marketable oxalic acid, free from superfluous moisture. Any hope of improvement seems directed rather to an economy of nitric acid, than to an increased production of oxalic acid from a given weight of sugar. The process is carried on either in large wooden vessels, or in small earthenware jars disposed in a water-bath, each jar having a capacity of about a gallon or less; the specific gravity of the nitric acid need not be so high when operating on the large scale, in a wooden trough, as when employing the earthenware jars. From 1.200 to 1.270 is the range; and the temperature in neither case should much exceed or fall short of 125° Fahr. The favourable symptoms are a regular and tolerably active evolution of gas without the appearance of red fumes, and a peculiar odour which only faintly recalls the smell of nitric oxide. The gases evolved consist, nevertheless, of nitric oxide and carbonic acid, but the influence of this latter gas has a remarkable effect in arresting the affinity of the nitric oxide for oxygen. So long as the carbonic acid is present, the mixture may be mingled with its own bulk of oxygen gas, without any diminution of volume, for several minutes, or the production of red fume; but the moment a little ammonia vapour is applied, so as to condense the

carbonic acid, the whole becomes of a deep orange hue. Herein lies a difficulty connected with the re-conversion of the nitric oxide into nitric acid by the action of atmospheric oxygen; and for the same reason, the employment of these gases in the manufacture of sulphuric acid has not answered the expectations of those who have tried the experiment practically. Carbonic acid would appear to possess, not simply a neutral agency in obstructing oxidation, but a negative power of preventing it. How far blowing atmospheric air through the acidulous saccharine solution, during the process of oxalic acid making, might tend to economize the consumption of nitric acid, we cannot pretend to say; but as the nitric acid really forms the chief item of expense, it is by such expedients that a saving may possibly be effected. When strong nitric acid is boiled upon sugar, in the way recommended in many chemical works, for the production of oxalic acid, a great loss of all the materials ensues; and most of the oxalic acid being peroxidized passes off as carbonic acid, leaving scarcely as much acid behind as is equivalent to half the weight of the sugar employed. This accounts for the discrepancies which have been published in this branch of manufacture.

Almost the only commercial article made from oxalic acid is the binoxalate of potash or salt of sorrel. This substance results from the decomposition of carbonate of potash by an excess of oxalic acid. The carbonate of potash is first dissolved in hot water, and the oxalic acid added until the effervescence ceases; after which a similar quantity of oxalic acid than that previously employed is thrown in, and the solution is boiled for a few minutes; and then it is set aside to crystallize. The crystals, after being drained and dried, are fit for the market.

Manufacture of Oxalic Acid. Oxalic acid is formed by the action of nitric acid on a great number of vegetable substances, such as sugar, rice, starch, washed sawdust, &c.

Sugar, either in its crystalline state, or in that of molasses or treacle, is the substance more commonly employed in the manufacture of oxalic acid.

On the addition of nitric acid to the saccharine solution and exposure to heat, a substitution of part of the oxygen of the nitric acid for the hydrogen of the sugar is effected, oxalic acid being formed, and binoxide of nitrogen evolved from the liquor. Other changes than this, however, take place; carbonic acid is often disengaged with the binoxide of nitrogen, and saccharic acid and other products remain in solution with the oxalic acid.

Instead of cane sugar or treacle, the saccharine substance formed by the action of sulphuric acid on potato or other starch (as in Mr. Nyren's process) is employed. For this purpose the potatoes are well washed, and then reduced into a fine pulp by rasping, grinding, or other suitable means; such pulp is then washed two or three times, by placing it in water and well stirring it therein, then permitting the pulp to subside, and running off the water. The pulp thus obtained is next placed in an open vessel of lead, or wood lined with lead, with as much water as will allow of the mixture being boiled freely, by means of steam passed through leaden pipes placed therein. Into the mixture of pulp and water, about 2 per cent. by weight (of the potatoes employed) of sulphuric acid is to be stirred in, which will be at the rate of from 8 to 10 per cent. of acid on the quantity of farina contained in the potatoes; the whole is now to be boiled for some hours, until the pulp of the potatoes is converted into saccharine matter, the completion of this process being readily ascertained by applying a drop of tincture of iodine to a small quantity of boiling liquor placed on the surface of a piece of glass, when, if there be any farina remaining unconverted, a purple colour will be produced. The saccharine product thus obtained is then filtered through a horse-hair cloth, after which it is carefully evaporated in any convenient vessel, until a gallon of it weighs about 14 or 14½ lbs.; it is now in a proper condition to be employed in the manufacture of oxalic acid, by the application of nitric acid, as in the case of operating from sugar or treacle. Horse-chestnuts, deprived of their outer shells, are also applicable to the manufacture of oxalic acid, when treated in the way above described for potatoes.

Instead of operating with sulphuric acid, the farina of potatoes and of chestnuts may be treated with diastase, and converted into a liquor similar to that obtained after evaporation from the farina and sulphuric acid before mentioned, using about the same proportion of diastase as before directed for sulphuric acid. In this case the liquor is made of the required strength at once, and the processes of filtration and evaporation are rendered unnecessary.

The apparatus required in the conversion of the saccharine matter (whether of cane sugar or formed of starch in the way above mentioned) into oxalic acid is very simple. Usually earthenware jars of about 2 gallons' capacity are employed, which, when charged with nitric acid and the saccharine material used, are placed in water-baths capable of holding a hundred or more of these jars. These baths are constructed of brick and lined with lead, and are heated by means of steam passed through coils of lead pipe placed therein.

Instead of earthenware jars, vessels of lead, or of wood lined with lead, may be em-

ployed in the manufacture of oxalic acid. For this purpose square open vessels, 8 ft. square and 3 ft. deep, are a convenient size, the liquor being heated by means of steam passed through a coil of lead pipe. A coil of about 48 ft. of one-inch pipe in a vessel of the size above mentioned, is sufficient to keep the liquor at the required temperature. In using these vessels, the liquor (whatever it may be) to be converted into oxalic acid is put into them together with the acid employed, and heated until the required decomposition is effected. The liquor is then drawn off by a syphon, or by a cock placed at the bottom of the vessel, into shallow leaden vessels, or wooden vessels lined with lead, to cool and crystallise, and the mother waters are drawn off from the crystals, and used in the next operation.

When the manufacture of this acid is conducted in large vessels, as above mentioned, the specific gravity of the nitric acid may be less than when the earthenware jars are used. From 1.200 to 1.270 are about the limits of the range allowed for the gravity of the acid. As regards the temperatures of the baths, this should be maintained at or about 125° Fahr. Whilst the operation is in progress, the active evolution of gas, without the appearance of red fumes, and the emission of a peculiar smell, slightly indicative of the presence of nitric oxide, are amongst the signs that every thing is in good working condition. The judicious addition of sulphuric acid is found to contribute to an increase of the quantity of oxalic acid produced. The product of acid from a given quantity of sugar has been much understated by chemical writers: this has most probably arisen from the circumstance of boiling the sugar with strong nitric acid, by which means a large quantity of oxalic acid becomes converted, as soon as formed, into carbonic acid, and the result is, that the actual product of oxalic acid obtained represents only about one-half of the sugar employed, and therefore not above one-half the quantity which should have been obtained. Thus we find it stated, that from 50 to 60 lbs. of oxalic acid are obtainable from 100 lbs. of good sugar, whereas the quantity actually obtained in practice is from 125 to 130 lbs. Treacle of course gives a smaller product; 100 lbs. of fair quality yielding from 105 to 110 lbs. of oxalic acid.

The mother liquor having been poured off, the crystals of acid obtained are thrown on drainers and washed, then carefully dried in a suitable stove. The mother liquors, when treated with a fresh supply of nitric acid and treacle, are ready for a further operation.

About 4½ cwts. of nitrate of soda, and 2½ cwts. of sulphuric acid, are used to furnish the nitric acid required to convert 1 cwt. of good sugar into oxalic acid.

Mr. Jullion has patented a process for the conversion of formic acid into oxalic acid. For this purpose, formic acid is saturated with a solution of caustic potash, and then half the quantity of caustic potash required for saturation is added to the above mixture; the whole is then evaporated to dryness, and heated to 560° Fahr. By this process, the formic acid is decomposed, and oxalate of potash formed. Caustic soda may also be employed instead of caustic potash.

The oxalate of potash or of soda thus obtained is then treated with sulphuret of barium, hydrate of baryta, or any soluble salt of baryta, whereby an oxalate of baryta is precipitated, from whence pure oxalic acid may be obtained by means of sulphuric acid.

Another mode of obtaining oxalic acid is by the process patented by Dr. Wilton Turner, who directs the uric acid obtained from guano to be treated with peroxide of lead or manganese suspended in water, at a boiling temperature, by which means it will be decomposed into oxalic acid, allantoin, urea. The oxalic acid forms an insoluble compound with the lead or manganese. The lead process is as follows: A known weight of uric acid is placed in an open cylindrical iron vessel, capable of holding two pounds of water for every pound of the acid, and adapted to boil by steam. A clear saturated solution of lime water is then added, and as soon as it is heated, and in brisk ebullition, the peroxide of lead is added in successive portions, as long as it is observed to be whitened by the boiling liquid. The whitish powder thus obtained is oxalate of lead. About 240 lbs. of peroxide of lead are required for each 168 lbs. of uric acid employed. The supernatant liquor is next drawn off, and the oxalate of lead washed with clear water; this is then boiled with dilute muriatic acid (equal parts of acid and water), by means of which oxalic acid is obtained in solution, which is evaporated and crystallized, whilst muriate of lead remains as the precipitate.

The allantoin is also decomposed into oxalic acid and ammonia by boiling it with caustic alkali. The former unites with the alkali used, while the ammonia passes over, and may be collected as liquid ammonia; the oxalic acid thus generated may be obtained as oxalate of potash, if potash be the alkali employed, or as oxalic acid if baryta be used, by decomposing the latter oxalate by means of sulphuric acid. In this case, the oxalate of baryta may be treated in the way previously described for oxalate of lead. This process is delusive.

As regards these various methods for obtaining oxalic acid, their employment will

of course always be a question of *£. s. d.*, the economy of many operations of manufacturing chemistry being often dependent upon their adaptation to the requirements or purposes of particular manufactures, in connection with other branches of manufacture carried on by them.

The low price at which treacle and sugar are now obtainable is much in favour of their use in this manufacture. The chief point, however, to which attention must be directed, in order to lessen the cost of production of this article, is in economising the nitric acid used.

In speaking of the action of nitric acid upon sugar, it was observed that carbonic acid was produced, and that it passes off with the deutoxide of nitrogen also set at liberty. The presence of carbonic acid, in this case, proves a great obstacle in the reconversion of nitric oxide into nitric acid, preventing the union of the oxygen of the air with the nitric oxide. Various processes have been from time to time suggested to effect this economy in the manufacture of oxalic acid: amongst these, the following may more particularly be noticed; —

In 1846, Mr. Jullion patented a method of converting the oxides of nitrogen, given off in the manufacture of oxalic acid, into nitrous and nitric acids. For this purpose, he uses a "generating vessel," which is a vessel something like a Woulfe's bottle, only having a movable top fitting air-tight, and capable of holding about 100 gallons. The materials to form the oxalic acid are introduced, and the vessel heated by a water-bath (by steam or other convenient means), which surrounds the vessel; a quantity of nitric acid is then added, and air or oxygen is forced in through a pipe inserted in the top. The oxygen, coming in contact with the evolved oxides of nitrogen, immediately converts a portion into nitrous and hyponitrous acids, which are partly again absorbed by the fluid in the vessel; another portion passes off by a pipe inserted in the upper part of the vessel, which pipe passes through a furnace. This part in the furnace is a little enlarged, and is heated from 600° to 900° Fahr.; this part of the pipe or tube contains spongy platinum, or other similar substances; the gases, in coming in contact with the heated platinum, combine to form nitric acid, which is afterwards condensed in vessels arranged as usual in the manufacture of this acid. Instead of platinum a close vessel containing water may be used, which decomposes hyponitrous and nitrous acids, giving rise to nitric acid. This principle is applied in the following ways:—the oxides of nitrogen, as evolved from the liquor in the decomposing vessel, coming in contact with oxygen, are converted into hyponitrous and nitrous acids, which, upon being mingled with steam, are decomposed into nitric acid and binoxide of nitrogen; or the introduction of steam may be obviated, by using heated air or oxygen in the decomposing vessels, by which means moisture will be furnished from the liquor; the amount of evaporation thus caused will also prevent an inconvenient increase of the mother-liquor. The compounds thus formed, when passed through suitable condensers, will, if the supply of atmospheric air or oxygen has been in excess, be all or nearly all condensed into nitric acid.

The following is a description of Crane and Jullion's continuous method of manufacturing oxalic acid and nitric acid at one process:—the oxalic acid mother-liquor of a previous process is placed in a closed or covered vessel, termed a "generator," formed of slate: nitric acid and syrup in the usual proportions employed for such quantity of mother-liquor are also placed separately in feeding vessels, over the "generator;" heat is then applied to the mother-liquor, and the temperature raised as quickly as possible to 180° or 200° Fahr. Streams of nitric acid and syrup are then caused to flow into the generator by means of suitable stop-cocks and funnel-pipes, in such a quantity that the delivery of the whole shall occupy about 18 hours, at the expiration of which time the process will be completed.

The gases arising from the decomposition of the materials so supplied pass off through an eduction pipe in the top of the generator, into a receiver, into which a stream of chlorine is introduced (from a chlorine generator) sufficient to convert the whole of the oxides of nitrogen into nitric acid. A portion of water in the receiver is decomposed, its oxygen combining with the oxide of nitrogen to form nitric acid, whilst its hydrogen combines with the chlorine to form hydrochloric acid. These mixed vapours pass over into suitable condensing vessels placed to receive them. The whole of the nitric acid and syrup having been run in, and the liberation of the gases or oxides of nitrogen having ceased, the oxalic acid liquor is drawn off from the generator and crystallized.

Messrs. McDougall and Rawson have patented a method of recovering the vapours which pass off in the manufacture of oxalic acid. To effect this, they direct the employment of a series of vessels containing water, into the first of which the nitrous gas or fumes are passed, through a tube dipping below the surface of the vessel; air is also admitted, which mixes with the gas bubbling up through the water. Attached to the last vessel of the series is a pneumatic apparatus, by means of which the mixture of

nitrous gas and air are drawn through this series of vessels, each containing a tube dipping into the liquid, and another tube or pipe attached to its top to connect it with the next vessel. The nitrous gas thus passing alternately into air and water, becomes converted into nitric acid. In this process, the following reaction is said to take place:—

On 3 N O being passed into water of the temperature of 100° Fahr. , or upwards, $2 \text{ N O}_2 + \text{N O}$ result, the 2 N O_2 , two atoms of nitric acid, remain in solution, whilst the N O , which is an incondensable gas, bubbles through the liquid, and unites with the air in the vessel above the liquid; it immediately takes two atoms of oxygen from the air, and becomes N O_2 , which passing through the liquid becomes nitric acid and nitrous gas, as before, and thus nearly the whole of the nitrous fumes or gas are reconverted into nitric acid.

In Eearnot's patented process for recovering the nitric acid, he fills his regenerating vessels with a porous substance, such as pumice-stone, supplying the oxygen by a blowing machine, a flow of steam being brought from a boiler.

Rationale of the Process for Oxalic Acid.—As no accurate account of the decomposition which ensues in the manufacture of oxalic acid has yet been published, that I am aware of, the following experiments may tend perhaps to draw attention to this subject.

The apparatus employed consisted of a large glass retort, placed in a water-bath, and luted to a tubulated receiver from the opening in which a tube passed into a two-necked bottle containing a solution of ammonia; this bottle was connected by a tube with another of the same size and form containing a solution of nitrate of lime, from which an exit tube passed which dipped under water, and allowed the escape of the incondensable gaseous matter.

The temperature of the water-bath was maintained as nearly as possible at 125° Fahr. for forty-eight hours in each experiment, after which the solution of oxalic acid was set aside for two days to crystallize. The crystals were allowed to effloresce in a drying stove, so as to remove all excess of nitric acid; they were then dissolved, recrystallized, dried and weighed.

The amount of carbonic acid was determined by mixing the solutions of ammonia, and nitrate of lime after each experiment, allowing the carbonate of lime to settle for four-and-twenty hours, after which it was washed, dried, and weighed. The sugar employed was the best refined white, and it lost nothing in weight by prolonged exposure to a temperature of 212° . The nitric acid was pure, and of specific gravity 1.245 at 60° ; it contained as nearly as possible one third of its weight of dry acid, as was proved by the amount of pure carbonate of soda which it neutralized. The following table exhibits the results of eight experiments, showing the amount of sugar and dilute nitric acid employed, and the quantity of oxalic and carbonic acids produced; the liquor from the receiver and the mother liquor of each experiment being added to the one following.

| Number. | Employed | | Obtained | |
|---------|------------------|-----------------------------|------------------------|--------------------------|
| | Sugar in Ounces. | Dil. Nitric Acid in Ounces. | Oxalic Acid in Ounces. | Carbonic Acid in Ounces. |
| 1. | 28 | 184 | $17\frac{1}{2}$ | $20\frac{1}{2}$ |
| 2. | 28 | 184 | $32\frac{1}{2}$ | $22\frac{1}{2}$ |
| 3. | 28 | 184 | 30 | 21 |
| 4. | 28 | 184 | $29\frac{1}{2}$ | $21\frac{1}{2}$ |
| 5. | 28 | 184 | $31\frac{1}{2}$ | 22 |
| 6. | 28 | 184 | $30\frac{1}{2}$ | 21 |
| 7. | 28 | 184 | $30\frac{1}{2}$ | $21\frac{1}{2}$ |
| 8. | 28 | 184 | 31 | $21\frac{1}{2}$ |

A large quantity of mother liquor remained, from which no crystals were attempted to be obtained, as these may be set against the small produce of experiment No. 1. If then we omit that experiment altogether, we shall have an average of the seven following, showing that 196 of sugar and 1288 of diluted nitric acid have produced $214\frac{1}{2}$ of oxalic acid, and $150\frac{1}{2}$ of carbonic acid, and that the proportion of carbon in the oxalic acid obtained almost exactly equals that in the carbonic acid, and that by the action of nitric acid in the way described, one half of the carbon of any given quantity of sugar is converted into oxalic acid, and the other half into carbonic acid. I have made many experiments with nitric acid of various densities and at various temperatures, but without obtaining in any instance so large a produce of oxalic acid, as with acid of the strength indicated. When strong acid is employed, the temperature rises too high, and a quantity of formic acid is occasionally produced, which distills over into the receiver and

materially diminishes the produce of oxalic acid. From these experiments it would appear that no more than 124 lbs. of oxalic acid can be obtained from 1 cwt. of sugar. This I am aware is much below the quantity generally supposed to be produced on the large scale, and which is stated to vary from 135 to 140 lbs. for the cwt. of sugar; such acid is, however, contaminated with nitric acid and mother liquor, and is moreover decidedly damp, as shown by the manner in which the crystals cling to the sides of the bottle in which they are contained; some allowance must also be made for the tendency to exaggeration which prevails in our manufactories. These proportions do not greatly differ from those employed in practice by oxalic acid makers, when allowance is made for the loss of nitric acid incidental to their mode of manufacture. The following is the general proportion of materials employed:—

| | | | | | |
|-------------------|---|---|---|---|----------|
| Sugar | - | - | - | - | 112 lbs. |
| Nitrate of potash | - | : | - | - | 560 lbs. |
| Sulphuric acid | - | - | - | - | 280 lbs. |

which are said to produce 135 lbs. of oxalic acid and 490 lbs. of sulphate of potash or sal-nitren.

Experiment has proved to me that the first change produced is to convert the cane sugar into grape sugar; and as the first portions of gas evolved consist almost entirely of nitric oxide with little or no carbonic acid, it is clear that some compound is generated in the commencement of this process, which contains the elements of sugar united to an excess of oxygen: the following diagram must therefore be looked on as merely explanatory of the ultimate change.

Of this, at least, I am sure that in some hundreds of attempts conducted on a pretty large scale, I have never once exceeded the amount here stated (124 lbs.), when the acid was properly purified and freed from adhering moisture. The following diagram, in my opinion, represents the nature of the ultimate decomposition which ensues in this manufacture, although other substances are unquestionably produced in the first instance. — *Lewis Thompson.*

| Materials employed | | Atoms | Products. |
|------------------------|------------|-------|-----------------------------|
| Common sugar, 1 atom - | Carbon - | 12 | 6 Carbonic acid. |
| | Hydrogen - | 11 | |
| | Oxygen - | 11 | |
| Nitric acid, 7 atoms - | Nitrogen - | 7 | 7 Deutoxide of Nitrogen. |
| | Oxygen - | 35 | |
| | | | 2 Water. |
| | | | 3 Crystallized oxalic acid. |

OXICHLORIDE OF LEAD. A white pigment patented by Mr. Hugh Lee Pattinson of Newcastle, which he prepares by precipitating a solution of chloride of lead in hot water with pure lime water, in equal measures; the mixture being made with agitation. As the operation of mixing the lime water, and the solution of chloride of lead, requires to be performed in an instantaneous manner, the patentee prefers to employ for this purpose two tumbling boxes of about 16 feet cubic capacity, which are charged with the two liquids, and simultaneously upset into a cistern in which oxichloride of lead is instantaneously formed, and from which the mixture flows into other cisterns, where the oxichloride subsides. This white pigment consists of one atom of chloride of lead and one atom oxide of lead, with or without an atom of water.

OXIDES, are neutral compounds, containing oxygen in equivalent proportion.

OXISELS, are salts, consisting of oxygenated acids and oxides, to distinguish them from the **HALOSELS,** which are salts consisting of one of the archæal elements: such as chlorine, iodine, bromine, &c. combined with metals. See **SALT.**

OXYGEN (*Oxigène, Fr.; Sauerstoff, Germ.*); can be examined only in the gaseous form, and is most conveniently obtained pure by exposing chlorate of potash, or red oxide of mercury, in a glass retort, to the heat of a spirit lamp; 100 grains of the salt yield 115 cubic inches of gas. One pound of nitre, ignited in an iron retort, gives out about 1200 cubic inches of oxygen, mixed with a little nitrogen. The peroxide of manganese alone, or mixed with a little chlorate of potash, also affords it, either by ignition alone in an iron or earthen retort, or by a lamp heat in a glass retort, when mixed with sulphuric acid. Oxygen is void of taste, colour, and smell. It possesses all the mechanical properties of the atmosphere. Its specific gravity is 1.1026 compared to air 1.0000; whence 100 cubic inches of it weigh 33.85 grains. Combustibles, even iron and diamonds, once kindled, burn in it most splendidly. It forms 21 parts in 100 by volume of air, being the constituent essential to the atmospheric functions of supporting animal and vegetable life, as well as flame. 3 parts of bichromate of

potash in powder, with 4 parts of oil of vitriol, when heated, afford oxygen gas plentifully.

The full development of this subject in its multifarious relations will be discussed in my forthcoming new system of chemistry.

OXYGENATED-MURIATIC, and OXYMURIATIC, are the names originally given by the French chemists, from false theoretical notions, to chlorine, which Sir H. Davy proved to be an undecomposed substance.

Oxygen in the atmosphere, method of determining the amount of. When some solution of caustic potash is conveyed into a tube filled with mercury, and then a solution of pyrogallic acid, the liquids mix without any alteration; but if now a bubble of oxygen or of air be passed into the tube, the liquid acquires a blackish red or nearly black colour, and the oxygen is as rapidly absorbed as carbonic acid by caustic potash. The quantity of oxygen which is absorbed under these circumstances by 1 part by weight of pyrogallic acid is enormous. According to the experiments of Dobereiner, 1 gramme of pyrogallic acid in an ammoniacal solution absorbs 0.38 gramme or 260 cub. centim. of oxygen; this is more than the quantity absorbed by 1 part in weight of sodium on its conversion into oxide, which only amounts to 236 cub. centim. In one experiment, which was made with especial care, a solution of 1 gramme pyrogallic acid in caustic potash absorbed 189.8 cub. centim. oxygen. Since 1 gramme hydrate of potash (K O, Aq), in order to pass into neutral carbonate, absorbs at 32° F. 192 cub. centim. carbonic acid, the absorbent capability of pyrogallic acid for oxygen, it will be seen, is not less than that of potash for carbonic acid. The following results, which were obtained with atmospheric air, will give an idea of the accuracy which is obtained by this method: —

| Number. | Volume of Air after Introduction of the Caustic Pot. ash. | Decrease in Volume after Introduction of Pyrogallic Acid. | Per cent. in Volume of Oxygen. |
|---------|---|---|--------------------------------|
| 1. | 221.5 | 46.5 | 20.99 |
| 2. | 201.0 | 42.0 | 20.89 |
| 3. | 193.0 | 40.6 | 21.03 |
| 4. | 210.0 | 44.0 | 20.95 |
| 5. | 204.5 | 42.5 | 20.77 |
| 6. | 195.0 | 40.8 | 20.92 |
| 7. | 200.0 | 41.8 | 20.90 |
| 8. | 200.0 | 41.6 | 20.80 |
| 9. | 200.0 | 41.5 | 20.75 |
| 10. | 236.0 | 49.0 | 20.76 |
| 11. | 258.0 | 54.0 | 20.93 |

With the expired air of different persons the following results were obtained, some with gallic, others with pyrogallic acid: —

| No. | Air. | Decrease in Volume by Solution of Pot. ash. | Decrease in Volume by Gallic or Pyrogallic Acid. | Volume of Nitrogen. |
|------|-------|---|--|---------------------|
| I. | 220.0 | 9.0 | 36.0 | 175.0 |
| II. | 221.5 | 9.0 | 36.0 | 175.5 |
| III. | 200.0 | 11.0 | 30.0 | 158.2 |
| IV. | 194.0 | 10.0 | 29.0 | 155.0 |

Consequently, the corresponding air in the experiments contains: —

| | I. | II. | III. | IV. |
|---------------|---------|-------|------|-------|
| Carbonic acid | - 4.09 | 4.06 | 5.5 | 5.41 |
| Oxygen | - 16.36 | 16.34 | 15.0 | 14.95 |
| Nitrogen | - 79.55 | 79.23 | 79.1 | 79.90 |

These analyses have only been made to test the method, and have no value in a physiological point of view.

The following was the mode of proceeding in the above mentioned analyses: — The air in which the amount of oxygen and carbonic acid was to be determined, was measured in graduated tubes over mercury. The tubes would contain about 30 cubic centim., each cubic centim. divided into 5 parts; they were filled $\frac{3}{4}$ with the air, the quantity read off, and now $\frac{1}{10}$ of its volume of solution of potash of 1.4 sp. gr. (one part dry

hydrate of potash to two parts water), introduced by means of the common pipette with curved point: by quickly moving up and down the tubes in the mercury, the solution of potash is spread over the whole inner surface of the tubes; and when no further decrease of space is perceptible, the decrease of volume is read off.

When the air has been previously dried by means of chloride of calcium, the decrease in volume accurately furnishes the amount of carbonic acid in the air; but if it were moist, the determination has an error attached to it, which is owing to the absorption of the aqueous vapour by the strong solution of potash.

After the carbonic acid has been determined, a solution of pyrogallic acid, containing one gramme of acid in 5 to 6 cub. centim. water, is introduced by means of a second pipette into the same tube, and amounting to about half the volume of the solution of potash. The same plan is adopted as in the determination of the carbonic acid, that is to say, the mixed liquids are well shaken over the inner surface of the tube, and when no further absorption is perceptible, the amount of nitrogen is measured off.

By mixing the solution of pyrogallic acid with the potash, the latter is diluted, and an error arises from the diminution of its tension; but this appears to be so exceedingly small, that it is not determinable; at the same time, it may easily be avoided, if, after the absorption of the oxygen, a piece of solid hydrate of potash, corresponding to the amount of water in the solution of pyrogallic acid, is introduced, and its solution awaited.

Ordinary gallic acid may be employed instead of the pyrogallic acid with the same result; but its employment has this inconvenience, that the absorption of the oxygen requires a much longer time, at least $1\frac{1}{2}$ to 2 hours, instead of as many minutes. Owing to the sparing solubility of gallic acid in water, it must be previously converted into gallate of potash, a cold saturated solution of which is employed. When this liquid is neutral, or contains a very slight excess of acid, it does not experience any alteration in the air. Its property of absorbing oxygen only becomes active in the presence of an excess of alkali.

When the gallic acid has been mixed with the caustic potash in the tube, the liquid on coming into contact with air containing oxygen, assumes a dark red colour; thin layers acquire almost a blood-red colour, which after a time passes into brown. By the production of this blood-red colour in the liquid, which moistens the sides of the tube on agitation, the progress of the absorption can be very distinctly traced; when this colouring is no longer exhibited, the operation is complete. With respect to the absorbent capacity of gallic acid for oxygen, it is known, from the experiments of Chevreul, that 1 gramme of gallic acid dissolved in strong potash absorbs 290 cub. centim., or nearly 0.417 gramme oxygen. In this respect it is in nowise inferior to pyrogallic acid.

Dr. Stenhouse has described a most excellent method for preparing pyrogallic acid. He obtained, by sublimation from the dry aqueous extract of the gall nuts, precisely in the same manner as benzoic acid is prepared from benzoin resin, above 10 per cent. in sublimed acid of the weight of the extract. When those who are engaged in photography have become convinced that in many cases pyrogallic acid is preferable to gallic acid, the increased demand for this acid will render its preparation still more productive.*

The principal error in the above eudiometrical process, which is scarcely to be got rid of, is occasioned by the difficulty of accurately reading off and determining the volume of the air, and its decrease from the absorption of the carbonic acid and of the oxygen, owing to the adhesion of the liquid to the sides of the tubes. This error becomes smaller when the precaution is adopted of using nearly the same volume of air for each analysis; but though this method admits of perfectly trustworthy determinations in comparative analyses, it will not supersede the processes of MM. Dumas and Bous-singault, or that of MM. Regnault and Reiset, or that of M. Bunzen for absolute determinations.

It need scarcely be mentioned, that the process described is only an application of the beautiful observations made by Chevreul and Dobereiner on gallic and pyrogallic acids, and that the merit of the discovery belongs to these illustrious individuals.

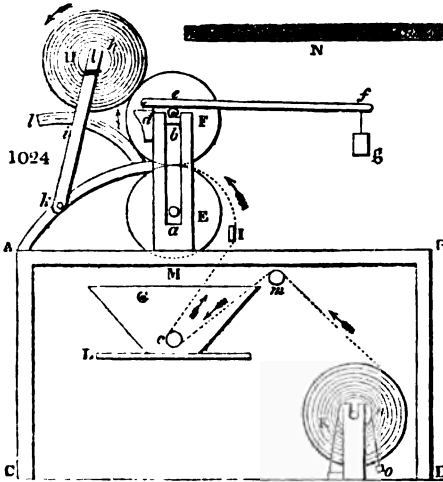
P.

PACKFONG, is the Chinese name of the alloy called white copper, or German silver.

PACO, or PACOS, is the Peruvian name of an earthy-looking ore, which consists of brown oxide of iron, with imperceptible particles of native silver disseminated through it.

* By the dry distillation of so-called Chinese galls, in small retorts capable of holding from 5 to 6 oz. in coarse fragments, a very concentrated solution of pyrogallic acid is obtained, which, evaporated on the water bath, yields of brown crystalline pyrogallic acid nearly 15 per cent. of the weight of the galls.

PADDING MACHINE (*Machine à plaquer*, Fr.; *Klatsch*, or *Grundirmaschine*, Germ.); in calico-printing, is the apparatus for uniformly with any mordant. In *fig. 1024*. A B C



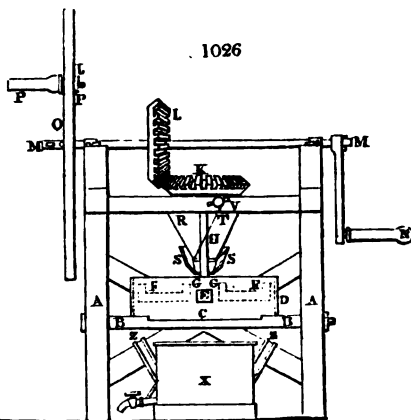
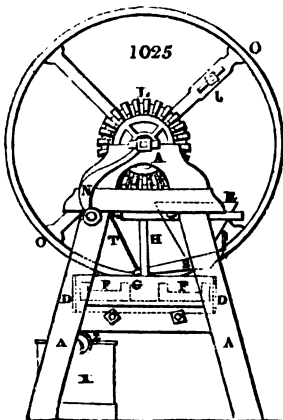
D represents in section a cast-iron frame, supporting two opposite standards above *m*, in whose vertical slot the gudgeons *a, b*, of two copper or bronze cylinders *x, r* run; the gudgeons of *x* turn upon fixed brasses or plummer blocks; but the superior cylinder *r* rests upon the surface of the under one, and may be pressed down upon it with greater or less force by means of the weighted lever *d e f g*, whose centre of motion is at *d*, and which bears down upon the axle of *r*. *x* is the roller upon which the pieces of cotton cloth intended to be padded are wound; several of them being stitched endwise together. They receive tension from the action of a weighted belt *o, n*, which passes round a pulley *n* upon the end of the roller *x*. The trough *c*, which contains the colouring matter or mordant, rests beneath the cylinder upon the table *l*, or other

convenient support. About two inches above the bottom of the trough, there is a copper dip-roller *c*, under which the cloth passes, after going round the guide roller *m*. Upon escaping from the trough, it is drawn over the half-round stretcher-bar at *l*, grooved obliquely right and left, as shown at *n*, whereby it acquires a diverging extension from the middle, and enters with a smooth surface between the two cylinders *x, r*. These are lapped round 6 or 7 times with cotton cloth, to soften and equalize their pressure. The piece of goods glides obliquely upwards, in contact with one third of the cylinder *r*, and is finally wound about the uppermost roller *n*. The gudgeon of *n* revolves in the end of the radius *h h*, which is jointed at *k*, and moveable by a mortise at *i* along the quadrantal arc towards *l*, as the roller *x* becomes enlarged by the convolutions of the web. The under cylinder *x* receives motion by a pulley or rigger upon its opposite end, from a band connected with the driving-shaft of the printshop. To ensure perfect equability in the application of the mordant, the goods are in some works passed twice through the trough; the pressure being increased the second time by sliding the weight *g* to the end of the lever *d f*.

A view of a padding machine in connexion with the driving mechanism is given under **HOT FLUX**; see also **STARCHING MACHINE**.

PAINT. See **ROUGE**.

PAINTS, GRINDING OF. There are many pigments, such as common orpi-



ment, or king's yellow, and verdigris, which are strong poisons; others which are very deleterious, and occasion dreadful maladies, such as white lead, red lead, chrome yellow, and vermilion; none of which can be safely ground by hand with the slab and muller, but should always be triturated in a mill. The emanations of white lead cause, first, that dangerous disease the *colica pictonum*, afterwards paralysis, or premature decrepitude and lingering death.

Figs. 1025, 26, 27, 28. exhibit the construction of a good colour-mill in three views;

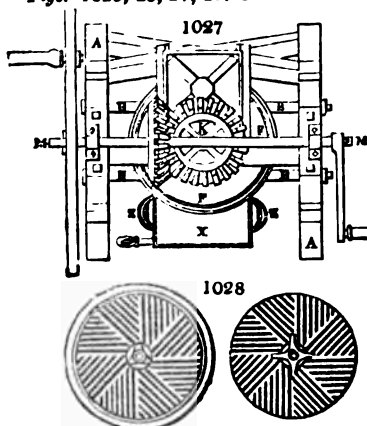


fig. 1025. being an elevation shown upon the side of the handle, or where the power is applied to the shaft; *fig. 1026.* a second elevation, taken upon the side of the line *c d*, of the plan or bird's-eye view, *fig. 1027.*

The frame-work *a a* of the mill is made of wood or cast-iron, strongly mortised or bolted together; and strengthened by the two cross iron bars *b, b*. *Fig. 1028.* is a plan of the millstones. The lying or nether millstone *c*, *fig. 1026.* is of cast iron, and is channelled on its upper face like corn millstones. It is fixed upon the two iron bars *b, b*; but may be preferably supported upon the 3 points of adjustable screws, passing up through bearing-bars. The millstone *c* is surrounded by a large iron hoop *d*, for preventing the pasty-consisted colour from running over

the edge. It can escape only by the sluice hole *z*, *fig. 1026.* formed in the hoop; and is then received in the tube *x* placed beneath.

The upper or moving millstone *r* is also made of cast iron. The dotted lines indicate its shape. In the centre it has an aperture with ledges *g, g*; there is also a ledge upon its outer circumference, sufficiently high to confine the colour which may occasionally accumulate upon its surface. An upright iron shaft *h* passes into the turning stone, and gives motion to it. A horizontal iron bevel wheel *x*, *figs. 1026, 1027.*, furnished with 27 wooden teeth, is fixed upon the upper end of the upright shaft *h*. A similar bevel wheel *l*, having the same number of teeth, is placed vertically upon the horizontal iron axis *m, m*, and works into the wheel *x*. This horizontal axis *m, m*, bears, at one of its ends, a handle or winch *n*, by which the workman may turn the millstone *r*; and on the other end of the same axis, the fly-wheel *o* is made fast, which serves to regulate the movements of the machine. Upon one of the spokes of the fly-wheel there is fixed, in like manner, a handle *r*, which may serve upon occasion for turning the mill. This handle may be attached at any convenient distance from the centre, by means of the slot and screw-nut *j*.

The colour to be ground is put into the hopper *a*, below which the bucket *s* is suspended, for supplying the colour uniformly through the orifice in the millstone *a*. A cord or chain *t*, by means of which the bucket *s* is suspended at a proper height for pouring out the requisite quantity of colour between the stones, pulls the bucket obliquely, and makes its beak rest against the square upright shaft *h*. By this means the bucket is continually agitated in such a way as to discharge more or less colour, according to its degree of inclination. The copper cistern *x*, receives the colour successively as it is ground; and, when full, it may be carried away by the two handles *z, z*; or it may be emptied by the stopcock *v*, without removing the tub.

PAINTS, VITRIFIABLE. See PORCELAIN, POTTERY, and STAINED GLASS.

PALLADIUM; a rare metal, possessed of valuable properties; was discovered in 1803, by Dr. Wollaston, in native platinum. It constitutes about 1 per cent. of the Columbian ore, and from $\frac{1}{4}$ to 1 per cent. of the Uralian ore of this metal; occurring nearly pure in loose grains, of a steel-gray colour, passing into silver white, and of a specific gravity of from 11.8 to 12.14; also as an alloy with gold in Brazil, and combined with selenium in the Harz near Tilkerode. Into the nitro-muriatic solution of native platinum, if a solution of cyanide of mercury be poured, the pale yellow cyanide of palladium will be thrown down, which being ignited affords the metal. This is the ingenious process of Dr. Wollaston. The palladium present in the Brazilian gold ore may be readily separated as follows: melt the ore along with 2 or 3 parts of silver, granulate the alloy, and digest it with heat in nitric acid of specific gravity 1.3. The solution containing the silver and palladium, for the gold does not dissolve, being

treated with common salt or muriatic acid, will part with all its silver in the form of a chloride. The supernatant liquor being concentrated and neutralized with ammonia, will yield a rose-coloured salt in long silky crystals, the ammonia-muriate of palladium, which being washed in ice-cold water, and ignited, will afford 40 per cent. of metal.

The metal obtained by this process is purer than that by the former; and if it be fused in a crucible along with borax, by the heat of a powerful air-furnace or forge, a button of malleable and ductile palladium will be produced. When a slip of it is heated to redness, it takes a bronze-blue shade of greater or less intensity, as the slip is cooled more or less slowly; but if it be suddenly chilled, as by plunging it into water, it resumes instantly its white lustre. This curious phenomenon depending upon oxidization and de-oxidization, in different circumstances, serves at once to distinguish palladium from platinum.

Pure palladium resembles platinum, but has more of a silver hue; when planished by the hammer into a cup, such as that of M. Breant, in the museum of the Mint at Paris, it is a splendid steel-white metal, not liable, like silver, to tarnish in the air. Another cup made by M. Breant, weighing 2 lbs. (1 kilogramme), was purchased by Charles X., and is now in the *garde-meuble* of the French government. The specific gravity of this metal, when laminated, is stated by Dr. Wollaston at 11.8, and by Vauquelin at 12.1. It melts at from 150° to 160° Wedgewood; and does not oxidize at a white heat. When a drop of tincture of iodine is let fall upon the surface of this metal, and dissipated over a lamp flame, a black spot remains, which does not happen with platinum. A slip of palladium has been used with advantage to inlay the limbs of astronomical instruments, where the fine graduated lines are cut, because it is bright, and not liable to alteration, like silver.

There are a protoxide and peroxide of palladium. The proto-chloride consists of 60 of metal and 40 of chlorine; the cyanide, of 67 of metal and 33 of cyanogen.

PALM OIL (*Huile de palme*, Fr.; *Palmböl*, Germ.); is obtained, in Guinea and Guyana, by expressing, as also by boiling, the fruit of the *avouira elais*. It has an orange colour, a smell of violets, a bland taste, is lighter than water, melts at 84° Fahr., becomes rancid and pale by exposure to air, dissolves in boiling alcohol, and consists of 69 parts of oleine, and 31 of stearine, in 100. It is employed chiefly for making yellow soap. It may be bleached by the action of either chlorine or oxygen gas, as also by that of light and heat.

Palm oil imported in 1850, 447,797 cwts., in 1851, 608,550 cwts.; exported in 1850, 73,186 cwts., in 1851, 114,952 cwts.

PAPER CLOTH. The preparation of this fabric is thus described in the specification of Mr. Henry Chapman's patent of January, 1843. A suitable quantity of canvass, gauze, muslin, calico, linen, &c., is wound upon a roller, which is introduced between the third press felt of a Fourdrinier paper machine; and between the above roller and the endless felt a trough is introduced, containing a solution of gum, glue, &c., with a roller partially immersed in it. Pulp being now allowed to flow upon the endless wire wheel of the machine, paper is made in the ordinary way; and when the endless sheet of paper has been led through the machine, the end of the cloth is brought over the upper part of the roller in the trough, and moved onwards in the direction the paper is proceeding. The motion of the cloth causes the roller to revolve, and the adhesive material carried upon its surface is imparted to the cloth, which is then laid upon the paper, as it passes over the roller immediately preceding the third or last press-roller. By passing between these rollers, the cloth and paper are firmly united, and being dried by the steam cylinders, form the compound fabric. If required, a paper surface may be applied to the other side of the cloth, by repeating the operation. If the cloth be dressed with strong starch, the bath of adhesive solution may be dispensed with. The following prescription is given for making that solution:—

Dissolve in 15 parts of water, 4 of soda, and combine with this solution, by means of heat, 9 parts of yellow rosin; boil for an hour, adding a little linseed oil to prevent frothing, and add 1 part of glue to the mixture; after which dilute the whole with one and a half times its weight of water, and strain through flannel. Thirty parts of this composition are to be mixed with one part of flour-paste, and six parts of paper-pulp, which mixture is to be used warm.

PAPER CUTTING. Mr. T. B. Crompton, of Farnworth, Lancashire, who obtained a patent in May, 1821, for proposing to conduct the newly formed web of paper in the Fourdrinier machine over heated cylinders, for the purpose of drying it expeditiously, in imitation of the mode so long practised in drying calicoes, obtained, along with Enoch Miller, another, in May, 1828, for cutting the endless web of paper lengthwise, by revolving circular blades, fixed upon a roller, parallel to a cylinder, round which the paper is lapped, and progressively unwound.

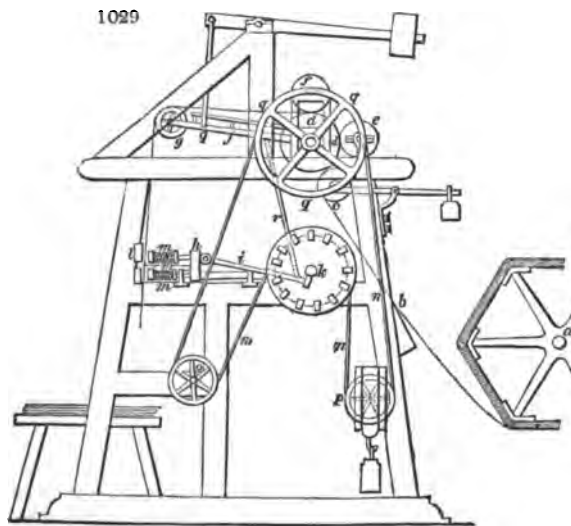
A patent had been obtained two months before, for certain improvements in cutting

paper, by Mr. Edward Cowper, consisting of a machine, with a reel on which the web of paper of very considerable length has been previously wound, in the act of being made in a Fourdrinier's machine; this web of paper being of sufficient width to produce two, three, or more sheets, when cut.

The several operative parts of the machine are mounted upon standards, or frame-work, of any convenient form or dimensions, and consist of travelling endless tapes to conduct the paper over and under a series of guide rollers; of circular rotatory cutters for the purpose of separating the web of paper into strips equal to the widths of the intended sheets; and of a saw-edged knife, which is made to slide horizontally for the purpose of separating the strips into such portions or lengths as shall bring them to the dimensions of a sheet of paper.

The end of the web of paper from the reel *a*, *fig* 1029., is first conducted up an inclined plane *b* by hand; it is then taken hold of by endless tapes extended upon rollers, as in Mr. Cowper's PRINTING MACHINE, which see. These endless tapes carry the web of paper to the roller *c*, which is pressed against the roller *d* by weighted levers, acting upon the plummer blocks that its axle is mounted in. The second roller *d* may be either of wood or metal, having several grooves formed round its periphery for the purpose of receiving the edges of the circular cutters *e*, (see CARD-CUTTING) mounted upon an axle turning upon bearings in the standards or frame.

In order to allow the web of paper to proceed smoothly between the two rollers *c*, *d*, a narrow rib of leather is placed round the edges of one or both of these rollers, for the



purpose of leaving a free space between them, through which the paper may pass without wrinkling.

From the first roller *c*, the endless tapes conduct the paper over the second *d*, and then under a pressing roller *f*, in which progress the edges of the circular knives *e*, revolving in the grooves of the second roller *d*, cut the web of paper longitudinally into strips of such widths as may be required, according to the number of the circular cutters and distances between them.

The strips of paper proceed onward from between the knife roller *d* and pressing roller *f*, conducted by tapes, until they reach a fourth roller *g*, when they are allowed to descend, and to pass through the apparatus designed to cut them transversely; that is, into sheet lengths.

The apparatus for cutting the strips into sheets is a sliding knife, placed horizontally upon a frame at *h*, which frame, with the knife *e*, is moved to and fro by a jointed rod *i*, connected to a crank on the axle of the pulley *k*. A flat board or plate *l* is fixed to the standard frame in an upright position, across the entire width of the machine and this board or

plate has a groove or opening cut along it opposite to the edge of the knife. The paper descending from the fourth roller *g* passes against the face of this board, and as the carriage with the knife advances, two small blocks, mounted upon rods with springs *m m*, come against the paper, and hold it tight to the board or plate *l*, while the edge of the knife is protruded forward into the groove of that board or plate, and its sharp saw-shaped teeth passing through the paper, cut one row of sheets from the descending strips; which, on the withdrawing of the blocks, falls down, and is collected on the heap below.

The power for actuating this machine is applied to the reverse end of the axle, on which the pulley *k* is fixed, and a band *n, n, n, n*, passing from this pulley over tension wheels *o*, drives the wheel *q* fixed to the axle of the knife roller *d*; hence this roller receives the rotatory motion which causes it to conduct forward the web of paper, but the other rollers *e* and *f*, are impelled solely by the friction of contact.

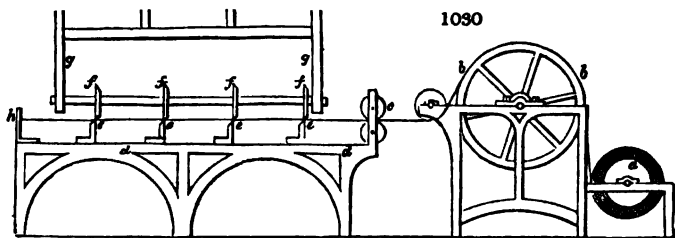
The rotation of the crank on the axle of *k*, through the intervention of the crank-rod *i*, moves the carriage *h*, with the knife, to and fro at certain periods, and when the spring blocks *m* come against the grooved plate *l*, they slide their guide rods into them while the knife advances to sever the sheets of paper. But as sheets of different dimensions are occasionally required, the lengths of the slips delivered between each return of the knife are to be regulated by enlarging or diminishing the diameter of the pulley *k*, which will of course retard or facilitate the rotation of the three conducting rollers, *e, d, f*, and cause a greater or less length of the paper to descend between each movement of the knife carriage.

The groove of this pulley *k*, which is susceptible of enlargement, is constructed of wedge-formed blocks passed through its sides, and meeting each other in opposite directions, so that on drawing out the wedges a short distance, the diameter of the pulley becomes diminished; or by pushing the wedges further in, the diameter is increased; and a tension wheel *p* being suspended in a weighted frame, keeps the band always tight.

As it is necessary that the paper should not continue descending while it is held by the blocks *m, m* to be cut, and yet that it should be led on progressively over the knife roller *d*, the fourth roller *g*, which hangs in a lever *j*, is made to rise at that time, so as to take up the length of paper delivered, and to descend again when the paper is withdrawn. This is effected by a rod *r*, connected to the crank on the shaft of the aforesaid roller *k*, and also to the under part of the lever *j*, which lever hanging loosely upon the axle of the knife roller *d*, as its fulcrum, vibrates with the under roller *g*, so as to effect the object in the way described.

The patentee states that several individual parts of this machine are not new, and that some of them are to be found included in the specifications of other persons, such as the circular cutters *e*, which are employed by Mr. Dickinson (CARD-CUTTING), and the horizontal cutter *h*, by Mr. Hansard; he therefore claims only the general arrangement of the parts in the form of a machine for the purpose of cutting paper, as the subject of his invention.

The machine for cutting paper contrived by John Dickinson, Esq., of Nash Mill, was patented in January, 1829. The paper is wound upon a cylindrical roller *a, fig.*



1030, mounted upon an axle, supported in an iron frame or standard. From this roller the paper in its breadth is extended over a conducting drum *b*, also mounted upon an axle turning in the frame or standard, and after passing under a small guide roller, it proceeds through a pair of drawing or feeding rollers *c*, which carry it into the cutting machine.

Upon a table *d, d*, firmly fixed to the floor of the building, there is a series of chisel-edged knives *e, e, e*, placed at such distances apart as the dimensions of the cut sheets of paper are intended to be. These knives are made fast to the table, and against them a series of circular cutters *f, f, f*, mounted in a swinging frame *g, g*, are intended

to act. The length of paper being brought along the table over the edges of the knives up to a stop *k*, the cutters are then swung forwards, and by passing over the paper against the stationary knives, the length of paper becomes cut into three separate sheets.

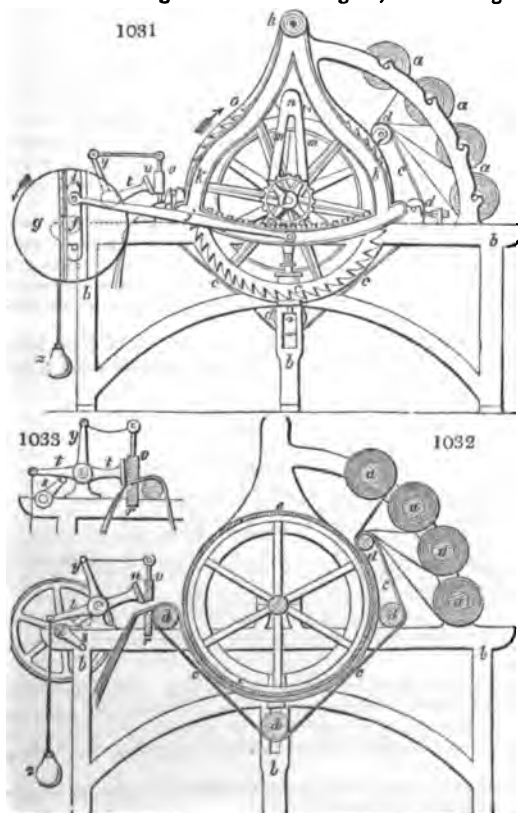
The frame *g, g*, which carries the circular cutters *f, f, f*, hangs upon a very elevated axle, in order that its pendulous swing may move the cutters as nearly in a horizontal line as possible; and it is made to vibrate to and fro by an eccentric, or crank, fixed upon a horizontal rotatory shaft extending over the drum *b*, considerably above it, which may be driven by any convenient machinery.

The workmen draw the paper from between the rollers *c*, and bring it up to the stop *k*, in the intervals between the passing to and fro of the swinging cutters.

The following very ingenious apparatus for cutting the paper web transversely into any desired lengths, was made the subject of a patent by Mr. E. N. Fourdrinier, in June, 1831, and has since been performing its duty well in many establishments.

Fig. 1031. is an elevation, taken upon one side of the machine; and fig. 1032. is a longitudinal section. *a, a, a, a*, are four reels, each covered with one continuous sheet of paper; which reels are supported upon bearings in the frame-work *b, b, b*. *c, c, c*, is an endless web of felt-cloth passed over the rollers *d, d, d, d*, which is kept in close contact with the under side of the drum *e, e*, seen best in fig. 1032.

The several parallel layers of paper to be cut, being passed between the drum *e*, and the endless felt *c*, will be drawn off their respective reels, and fed into the machine, whenever the driving-band is slid from the loose to the fast pulley upon the end of the main shaft *f*. But since the progressive advance of the paper-webs must be arrested during the time of making the cross cut through it, the following apparatus becomes necessary.



A disc *g*, which carries the pin or stud of a crank *i*, is made fast to the end of the driving shaft *f*. This pin is set in an adjustable sliding piece, which may be confined by a screw within the beveled graduated groove, upon the face of the disc *g*, at variable distances from the axis, whereby the eccentricity of the stud *i*, and of course the throw of the crank, may be considerably varied. The crank stud *i* is connected by its rod *j*, to the swinging curvilinear rack *k*, which takes into the toothed wheel *l*, that turns freely upon the axle of the feed drum *e, e*. From that wheel the arms *m, m*, rise, and bear one or more palls *n*, which work in the teeth of the great ratchet wheel *o, o*, mounted upon the shaft of the drum *e*.

The crank-plate *g* being driven round in the direction of its arrow, will communicate a see-saw movement to the toothed arc *k*, next to the toothed wheel *l* in gearing with it, and an oscillatory motion to the arms *m, m*, as also to their surmounting pall *n*. In its swing to the left hand,

the catch of the pall will slide over the slope of the teeth of the ratchet wheel *o*; but in its return to the right hand, it will lay hold of these teeth, and pull

them, with their attached drum, round a part of a revolution. The layers of paper in close contact with the under half of the drum, will be thus drawn forward at intervals, from the reels, by the friction between its surface and the endless felt, and in lengths corresponding to the arc of vibration of the pall. The knife for cutting these lengths transversely is brought into action at the time when the swing arc is making its inactive stroke, viz., when it is sliding to the left over the slopes of the ratchet teeth *o*. The extent of this vibration varies according to the distance of the crank stud *i*, from the centre *f*, of the plate *g*, because that distance regulates the extent of the oscillations of the curvilinear rack, and that of the rotation of the drum *e*, by which the paper is fed forwards to the knife apparatus. The proper length of its several layers being by the above described mechanism carried forward over the bed *r* of the cutting knife or shears *r, v*, whose under blade *r* is fixed, the wiper *s*, in its revolution with the shaft *f*, lifts the tail of the lever *t*, consequently depresses the transverse movable blade *v* (as shown in *fig. 1033.*), and slides the slanting blades across each other obliquely, like a pair of scissors, so as to cause a clean cut across the plies of paper. But just before the shears begin to operate, the transverse board *u* descends to press the paper with its edge, and hold it fast upon the bed *r*. During the action of the upper blade *v*, against the under *r*, the fall board *u* is suspended by a cord passing across pulleys from the arm *y* of the bell-crank lever *t, t*. Whenever the lifter cam *s* has passed away from the tail of the bell-crank *t*, the weight *z*, hung upon it, will cause the blade *v*, and the pinching board *u*, to be moved up out of the way of the next length of paper, which is regularly brought forward by the rotation of the drum *e*, as above described. The upper blade of the shears is not set parallel to the shaft of the drum, but obliquely to it, and is, moreover, somewhat curved, so as to close its edge progressively upon that of the fixed blade. The blade *v* may also be set between two guide pieces, and have the necessary motion given to it by levers. See LABOUR SAVING MACHINES.

PAPER-HANGINGS, called more properly by the French, *papiers peints*. The art of making paper-hangings, *papier de tenture*, has been copied from the Chinese, among whom it has been practised from time immemorial. The English first imported and began to imitate the Chinese paper hangings; but being exposed till very lately to a high excise duty upon the manufacture, they have not carried it to that extent and pitch of refinement which the French genius has been enabled to do, unchecked by taxation. The first method of making this paper was stencilling; by laying upon it, in an extended state, a piece of pasteboard having spaces cut out of various figured devices, and applying different water colours with the brush. Another piece of pasteboard with other patterns cut out was next applied, when the former figures were dry, and new designs were thus imparted. By a series of such operations, a tolerable pattern was executed, but with no little labour and expense. The processes of the calico printer were next resorted to, in which engraved blocks of the pear or sycamore were employed to impress the coloured designs.

Paper-hangings may be distinguished into two classes; 1. those which are really painted, and which are designed in France under the title of *papiers peints*, with brilliant flowers and figures; and 2. those in which the designs are formed by foreign matters applied to the paper, under the name of *papier tentise*, or flock paper.

The operations common to paper-hangings of both kinds may be stated as follows:—

1. The paper should be well sized.
2. The edges should be evenly cut by an apparatus like the bookbinder's press.
3. The ends of each of the 24 sheets which form a piece, should be nicely pasted together; or a Fourdrinier web of paper should be taken.
4. Laying the grounds is done with earthy colours or coloured lakes thickened with size, and applied with brushes.

An expert workman, with one or two children, can lay the grounds of 300 pieces in a day. The pieces are now suspended upon poles near the ceiling, in order to be dried. They are then rolled up and carried to the apartment where they are polished, by being laid upon a smooth table, with the painted side undermost, and rubbed with the polisher. Pieces intended to be satined are grounded with fine Paris plaster, instead of Spanish white; and are not smoothed with a brass polisher, but with a hard brush attached to the lower end of the swing polishing rod. After spreading the piece upon the table with the grounded side undermost, the paper-stainer dusts the upper surface with finely powdered chalk of Briançon, commonly called tale, and rubs it strongly with the brush. In this way the satiny lustre is produced.

THE PRINTING OPERATIONS.

Blocks about two inches thick, formed of three separate boards glued together, of which two are made of poplar, and one (that which is engraved) of pear-tree or sycamore.

more, are used for printing paper-hangings, as for calicoes. The grain of the upper layer of wood should be laid across that of the layer below. As many blocks are required as there are colours and shades of colour. To make the figure of a rose, for example, three several reds must be applied in succession, the one deeper than the other, a white for the clear spaces, two and sometimes three greens for the leaves, and two wood colours for the stems; altogether from 9 to 12 for a rose. Each block carries small pin points fixed at its corners to guide the workman in the insertion of the figure exactly in its place. An expert hand places these guide pins so that their marks are covered and concealed by the impression of the next block; and the finished piece shows merely those belonging to the first and last blocks.

In printing, the workman employs the same *swimming-tub* apparatus which has been described under block printing (see CALICO-PRINTING), takes off the colour upon his blocks, and impresses them on the paper extended upon a table in the very same way. The tub in which the drum or frame covered with calf-skin is inverted, contains simply water thickened with parings of paper from the bookbinder, instead of the pasty mixture employed by the calico-printers. In impressing the colour by the block upon the paper, he employs a lever of the second kind, to increase the power of his arm, making it act upon the block through the intervention of a piece of wood, shaped like the bridge of a violin. This tool is called *tasseau* by the French. A child is constantly occupied in spreading colour with a brush upon the calf-skin head of the drum or sieve, and in sliding off the paper upon a wooden trestle or horse, in proportion as it is finished. When the piece has received one set of coloured impressions, the workman, assisted by his little aid called a *stieur* (drawer), hooks it upon the drying-poles under the ceiling. A sufficient number of pieces should be provided to keep the printer occupied during the whole at least of one day, so that they will be dried and ready to receive another set of coloured impressions by the following morning.

All the colours are applied in the same manner, every shade being formed by means of the blocks, which determine all the beauty and regularity of the design. A pattern drawer of taste may produce a very beautiful effect. The history of Psyche and Cupid, by M. Dufour, has been considered a masterpiece in this art, rivaling the productions of the pencil in the gradation, softness, and brilliancy of the tints.

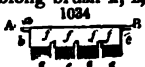
When the piece is completely printed, the workman looks it all over, and if there be any defects, he corrects them by the brush or pencil, applying first the correction of one colour, and afterwards of the rest.

A final satining, after the colours are dried, is communicated by the friction of a finely polished brass roller, attached by its end gudgeons to the lower extremity of a long swing-frame; and acting along the cylindrical surface of a smooth table, upon which the paper is spread.

The *fonds* or rainbow style of paper-hangings, which I have referred to this place in the article CALICO-PRINTING, is produced by means of an assortment of oblong narrow tin pans, fixed in a frame, close side to side, each being about one inch wide, two inches deep, and eight inches long; the colours of the prismatic spectrum, red, orange, yellow, green, &c., are put, in a liquid state, successively in these pans; so that when the oblong brush *A, B*, with guide ledges *a, c, d*, is dipped into them across the whole of the parallel row at once, it comes out impressed with the different colours at successive points *e, e, e, e*, of its length, and is then drawn by the paper-stainer over the face of the woollen drum head, or sieve of the swimming tub, upon which it leaves a corresponding series of stripes in colours, graduating into one another like those of the prismatic spectrum. By applying his block to the *tear*, the workman takes up the colour in rainbow hues, and transfers these to the paper. *f, f, f, f* show the separate brushes in tin sheaths, set in one frame.

At M. Zuber's magnificent establishment in the ancient chateau of Rixheim, near Mulhouse, where the most beautiful French *papiers peints* are produced, and where I was informed that no less than 3000 blocks are required for one pattern, I saw a two-colour calico machine employed with great advantage, both as to taste and expedition. Steam-charged cylinders were used to dry the paper immediately after it was printed, as the colours, not being so rapidly absorbed as they are by calico, would be very apt to spread.

The operations employed for common paper-hangings, are also used for making flock paper, only a stronger size is necessary for the ground. The flocks are obtained from the woollen cloth manufacturers, being cut off by their shearing machines, called *lewises* by the English workmen, and are preferred in a white state by the French paper-hanging makers, who scour them well, and dye them of the proper colours themselves. When they are thoroughly stove-dried, they are put into a conical fluted mill, like that for making snuff, and are properly ground. The powder thus obtained is afterwards sifted by a bolting-machine, like that of a flour mill, whereby flocks of different degrees of fineness are produced. These are applied to the paper after it has undergone all the



usual printing operations. Upon the workman's left hand, and in a line with his printing table, a large chest is placed for receiving the flock powders: it is seven or eight feet long, two feet wide at the bottom, three feet and a half at top, and from 15 to 18 inches deep. It has a hinged lid. Its bottom is made of tense calf-skin. This chest is called the *drum*; it rests upon four strong feet, so as to stand from 24 to 28 inches above the floor.

The block which serves to apply the adhesive basis of the velvet-powders, bears in relief only the pattern corresponding to that basis, which is formed with linseed oil, rendered drying by being boiled with litharge, and afterwards ground up with white lead. The French workmen call this mordant the *encaustic*. It is put upon the cloth which covers the inverted swimming tub, in the same way as the common colours are, and is spread with a brush by the *tireur* (corruptly styled *tearer* by some English writers). The workman daubs the blocks upon the mordant, spreads the pigment even with a kind of brush, and then applies it by impression to the paper. Whenever a sufficient surface of the paper has been thus covered, the child draws it along into the great chest, sprinkling the flock powder over it with his hands; and when a length of 7 feet is printed, he covers it up within the drum, and beats upon the calf-skin bottom with a couple of rods to raise a cloud of flock inside, and to make it cover the prepared portion of the paper uniformly. He now lifts the lid of the chest, inverts the paper, and beats its back lightly, in order to detach all the loose particles of the woolly powder.

By the operation just described, the velvet-down being applied every where of the same colour, would not be agreeable to the eye, if shades could not be introduced to relieve the pattern. To give the effect of drapery, for example, the appearance of folds must be introduced. For this purpose, when the piece is perfectly dry, the workman stretches it upon his table, and by the guidance of the pins in his blocks, he applies to the flock surface a colour in distemper, of a deep tint, suited to the intended shades, so that he dyes the wool in its place. Light shades are produced by applying some of his lighter water-colours.

Gold leaf is applied upon the above mordant, when nearly dry; which then forms a proper gold size; and the same method of application is resorted to, as for the ordinary gilding of wood. When the size has become perfectly hard, the superfluous gold leaf is brushed off with a dossil of cotton wool or fine linen.

The colours used by the paper-hangers are the following:—

1. *Whites*. These are either white-lead, good whitening, or a mixture of the two.
2. *Yellows*. These are frequently vegetable extracts; as those of weld, or of Avignon or Persian berries, and are made by boiling the substances with water. Chrome yellow is also frequently used, as well as the *terra di Sienna* and yellow ochre.
3. *Reds* are almost exclusively decoctions of Brazil wood.
4. *Blues* are either prussian blue, or blue verditer.
5. *Greens*, are Scheele's green, a combination of arsenious acid, and oxide of copper; the green of Schweinfurth, or green verditer; as also a mixture of blues and yellows.
6. *Violets* are produced by a mixture of blue and red in various proportions, or they may be obtained directly by mixing a decoction of logwood with alum.
7. *Browns, blacks, and grays*. Umber furnishes the brown tints. Blacks are either common ivory or Frankfort black; and grays are formed by mixtures of prussian blue and Spanish white.

All the colours are rendered adhesive and consistent, by being worked up with gelatinous size or a weak solution of glue, liquefied in a kettle. Many of the colours are previously thickened, however, with starch. Sometimes coloured lakes are employed. See *LAKES*.

PAPER, MANUFACTURE OF. (*Papeterie*, Fr.; *Papiermacherskunst*, Germ.)

This most useful substance, which has procured for the moderns an incalculable advantage over the antients, in the means of diffusing and perpetuating knowledge, seems to have been first invented in China, about the commencement of the Christian era, and was thence brought to Mecca, along with the article itself, about the beginning of the 8th century; whence the Arabs carried it, in their rapid career of conquest and colonization, to the coasts of Barbary, and into Spain, about the end of the 9th or beginning of the 10th century.

By other accounts, this art originated in Greece, where it was first made from cotton fibres, in the course of the tenth century, and continued there in common use during the next three hundred years. It was not till the beginning of the 14th century that paper was made from linen in Europe, by the establishment of a paper-mill in 1390, at Nuremberg in Germany. The first English paper-mill was erected at Dartford by a German jeweller in the service of Queen Elizabeth, about the year 1588. But the business was not very successful; in consequence of which, for a long period afterwards, indeed till within the last 70 years, this country derived its supplies of fine writing papers from France and Holland. Nothing places in a more striking light the

vast improvement which has taken place in all the mechanical arts of England since the era of Arkwright, than the condition of our paper-machine factories now, compared with those on the Continent. Almost every good automatic paper mechanism at present mounted in France, Germany, Belgium, Italy, Russia, Sweden, and the United States, has either been made in Great Britain, and exported to these countries, or has been constructed in them closely upon the English models.

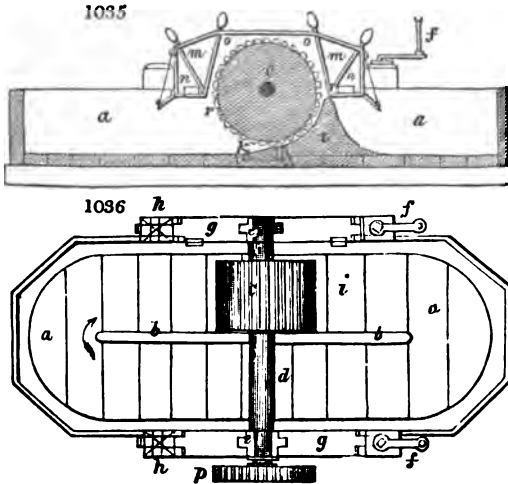
Till within the last 30 years, the linen and hempen rags from which paper was made, were reduced to the pasty state of comminution requisite for this manufacture by mashing them with water, and setting the mixture to ferment for many days in close vessels, whereby they underwent in reality a species of putrefaction. It is easy to see that the organic structure of the fibres would be thus unnecessarily altered, nay, frequently destroyed. The next method employed, was to beat the rags into a pulp by stamping rods, shod with iron, working in strong oak mortars, and moved by water-wheel machinery. So rude and ineffective was the apparatus, that forty pairs of stamps were required to operate a night and a day, in preparing one hundred weight of rags. The pulp or paste was then diffused through water, and made into paper by methods similar to those still practised in the small hand-mills.

About the middle of the last century, the cylinder or engine mode, as it is called, of comminuting rags into paper pulp, was invented in Holland; which was soon afterwards adopted in France, and at a later period in England.

The first step in the paper manufacture, is the sorting of the rags into four or five qualities. They are imported into this country chiefly from Germany, and the ports of the Mediterranean. At the mill they are sorted again more carefully, and cut into shreds by women. For this purpose a table frame is covered at top with wire cloth, containing about nine meshes to the square inch. To this frame a long steel blade is attached in a slanting position, against whose sharp edge the rags are cut into squares or fillets, after having their dust thoroughly shaken out through the wire cloth. Each piece of rag is thrown into a certain compartment of a box, according to its fineness; seven or eight sorts being distinguished. An active woman can cut and sort nearly one cwt. in a day.

The sorted rags are next dusted in a revolving cylinder surrounded with wire cloth, about six feet long, and four feet in diameter, having spokes about 20 inches long, attached at right angles to its axis. These prevent the rags from being carried round with the case, and beat them during its rotation; so that in half an hour, being pretty clean, they are taken out by the side door of the cylinder, and transferred to the engine, to be first washed, and next reduced into a pulp. For fine paper, they should be previously boiled for some time in a caustic lye, to cleanse and separate their filaments.

The construction of the *stuff-engine* is represented in *figs.* 1035, 6. *Fig.* 1035. is the longitudinal section, and *fig.* 1036. the plan of the engine.



The large vat is an oblong cistern rounded at the angles. It is divided by the partition *b, b*, and the whole inside is lined with lead. The cylinder *c*, is made fast to the spindle *d*, which extends across the engine, and is put in motion by the pinion *p*, fixed to its extremity. The cylinder is made of wood, and furnished with a number of blades or cutters, secured to its circumference, parallel to the axis, and projecting about an inch above its surface. Immediately beneath the cylinder a block of wood *h* is placed. This is mounted with cutters like those of the cylinder, which in their

revolution pass very near to the teeth of the block, but must not touch it. The distance between these fixed and moving blades is capable of adjustment by elevating or depressing the bearings upon which the necks *e, e*, of the shaft are supported. These bearings rest upon two levers *g, g*, which have tenons at their ends, fitted into upright mortises, made in short beams *h, h*, bolted to the sides of the engine. The one end of

the levers g, g , is movable, while the other end is adapted to rise and fall upon bolts in the beams h, h , as centres. The front lever, or that nearest to the cylinder c , is capable of being elevated or depressed, by turning the handle of a screw (not seen in this view), which acts in a nut fixed to the tenon of g , and comes up through the top of the beam h , upon which the head of the screw takes its bearing. Two brasses are let into the middle of the levers g, g , and form the bearings for the shaft of the engine to turn upon. The above-mentioned vertical screw is used to raise or lower the cylinder, and cause it to cut coarser or finer, by enlarging or diminishing the space between the fixed cutters in the block and those in the cylinder.

To the left hand of t , *fig.* 1035, is a circular breasting made of boards, and covered with sheet lead; it is curved to fit the cylinder very truly, and leaves but very little space between the teeth and breasting; at its bottom, the block k is fixed. The engine is supplied with water from a pump, by a pipe, which delivers it into a small cistern, near to and communicating with the engine. A stopcock cuts off or regulates the supply of water at pleasure, and a grating covered with hair-cloth is fixed across that small cistern, to intercept any filth that may be floating in the water; in other cases a flannel bag is tied round the nose of the stopcock, to act as a filter.

The rags being put into the engine filled with water, are drawn by the rapid rotation of the cylinder between the two sets of cutters, whereby they are torn into the finest filaments, and by the impulsion of the cylinder they are floated over the top of the breasting upon the inclined plane. In a short time more rags and water are raised into that part of the engine vat. The tendency in the liquid to maintain an equilibrium, puts the whole contents of the cistern in slow motion down the inclined plane, to the left hand of t , and round the partition b, b , (see the arrow), whereby the rags come to the cylinder again in the space of about 20 minutes; so that they are repeatedly drawn out and separated in all directions till they are reduced to the appearance of a pulp.

This circulation is particularly useful, by turning over the rags in the engine, causing them to be presented to the cutter at different angles every time; otherwise, as the blades always act in one direction, the comminution would not be so complete. The cutting is performed as follows: The teeth of the block are set somewhat obliquely to the axes of the cylinder, as shown by *fig.* 1037; but the teeth of the cylinder c itself are set parallel to its axis; therefore the cutting edges meet at a small angle, and come in contact, first at the one end, and then towards the other, by successive degrees, so that any rags coming between them, are torn as if between the blades of a pair of forceps. Sometimes the blades k in the block are bent to an angle in the middle, instead of being straight and inclined to the cylinder. These are called elbow plates; their

1037



two ends being inclined in opposite directions to the axis of the cylinder. In either case, the edges of the plates of the block cannot be straight lines, but must be curved, to adapt themselves to the curve which a line traced on the cylinder will necessarily have. The plates or blades are united by screwing them together, and fitting them into a cavity cut into the wooden block k . Their edges are bevelled away upon one side only.

The block is fixed in its place by being made dovetailed, and truly fitted into the bottom of the cistern, so that the water will not leak through its junction. The end of it comes through the woodwork of the chest, and projects to a small distance on its outside, being kept in its place by a wedge. By withdrawing this wedge, the block becomes loose, and can be removed in order to sharpen the cutters, as occasion may be. This is done at a grindstone, after detaching the plates from each other.

The cutters of the cylinder, are fixed into grooves, cut in the wood of the cylinder, at equal distances asunder, round its periphery, in a direction parallel to its axis. The number of these grooves is twenty, in the machine here represented. For the *washer*, each groove has two cutters put into it; then a fillet of wood is driven fast in between them, to hold them firm; and the fillets are secured by spikes driven into the solid wood of the cylinder. The *beater* is made in the same manner, except that each groove contains three bars and two fillets.

In the operation of the cylinder, it is necessary that it should be enclosed in a case, or it would throw all the water and rags out of the engine, in consequence of its great velocity. This case is a wooden box m, m , *fig.* 1035, enclosed on every side except the bottom; one side of it rests upon the edge of the vat, and the other upon the edge of the partition b, b , *fig.* 1036. The diagonal lines m, r , represent the edges of wooden frames, which are covered with hair or wire cloth, and immediately behind these the box is furnished with a bottom and a ledge towards the cylinder, so as to form a complete trough. The square figures under n, n , in *fig.* 1035, show the situation of two openings or spouts through the side of the case, which conduct to flat lead-pipes, one of which is seen near the upper g in *fig.* 1036, placed by the side of the vat; the beam being cut away from them. These are waste pipes to discharge the foul water from the engine; because the

cylinder, as it turns, throws a great quantity of water and rags up against the sieves; the water goes through them, and runs down to the trough under *n, n*, and thence into the ends of the flat leaden pipes, through which it is discharged. *o, o, fig. 1035.*, are grooves for two boards, which, when put down in their places, cover the hair sieves, and stop the water from going through them, should it be required in the engine. This is always the case in the beating engines, and therefore they are seldom provided with these waste pipes, or at most on one side only; the other side of the cover being curved to conform to the cylinder. Except this, the only difference between the washing engine and the beater, is that the teeth of the latter are finer, there being 60 instead of 40 blades in the periphery; and it revolves quicker than the washer, so that it will tear out and comminute those particles which pass through the teeth of the washer. In small mills, when the supply of water is limited, there is frequently but one engine, which may be used both for washing and beating, by adjusting the screw so as to let the cylinder down and make its teeth work finer. But the system in all considerable works, is to have two engines at least, or four if the supply of water be great. The power required for a 5 or 6 vat mill, is about 20 horses in a water-wheel or steam engine.

In the above figures only one engine is shown, namely, the *finisher*; there is another, quite similar, placed at its end, but on a level with its surface, which is called the *washer*, in which the rags are first worked coarsely with a stream of water, running through them to wash and open their fibres; after this washing they are called *half-stuff*, and are then let down into the bleaching engine, and next into the *beating* engine, above described.

By the arrangements of the mill gearing, the two cylinders of the *washer* and *beater* engines make from 120 to 150 revolutions per minute, when the water-wheel moves with due velocity. The beating engine is always made to move, however, much faster than the washing one, and nearly in the ratio of the above numbers.

The vibratory noise of a washing engine is very great; for when it revolves 120 times per minute, and has 40 teeth, each of which passes by 12 or 14 teeth in the block at every revolution, it will make nearly 60,000 cuts in a minute, each of them sufficiently loud to produce a most grating growling sound. As the beater revolves quicker, having perhaps 60 teeth, instead of 40, and 20 or 24 cutters in the block, it will make 180,000 cuts in a minute. This astonishing rapidity produces a coarse musical humming, which may be heard at a great distance from the mill. From this statement, we may easily understand how a modern engine is able to turn out a vastly greater quantity of paper pulp in a day than an old mortar machine.

The operation of grinding the rags requires nice management. When first put into the washing engine they should be worked gently, so as not to be cut, but only powerfully scrubbed, in order to enable the water to carry off the impurities. This effect is obtained by raising the cylinder upon its shaft, so that its teeth are separated considerably from those of the block. When the rags are comminuted too much in the washer, they would be apt to be carried off in part with the stream, and be lost; for at this time the water-cock is fully open. After washing in this way for 20 or 30 minutes, the bearings of the cylinder are lowered, so that its weight rests upon the cutters. Now the supply of water is reduced, and the rags begin to be torn, at first with considerable agitation of the mass, and stress upon the machinery. In about three or four hours, the engine comes to work very smoothly, because it has by this time reduced the rags to the state of *half-stuff*. They are then discharged into a large basket, through which the water drains away.

The bleaching is usually performed upon the *half-stuff*. At the celebrated manufactory of Messrs. Montgolfier, at Annonay, near Lyons, chlorine gas is employed for this purpose with the best effect upon the paper, since no lime or muriate of lime can be thus left in it; a circumstance which often happens to English paper, bleached in the washing engine by the introduction of chloride of lime among the rags, after they have been well washed for three or four hours by the rotation of the engine. The current of water is stopped whenever the chloride of lime is put in. From 1 to 2 pounds of that chemical compound are sufficient to bleach 1 cwt. of fine rags, but more must be employed for the coarser and darker coloured. During the bleaching operation the two sliders *o, o, fig. 1035.*, are put down in the cover of the cylinder, to prevent the water getting away. The engine must be worked an hour longer with the chloride of lime, to promote its uniform operation upon the rags. The cylinder is usually raised a little during this period, as its only purpose is to agitate the mass, but not to triturate it. The water-cock is then opened, the boards *m, m* are removed, and the washing is continued for about an hour, to wash the salt away; a precaution which ought to be better attended to than it always is by paper manufacturers.

The *half-stuff* thus bleached, is now transferred to the beating engine, and worked into a fine pulp. This operation takes from 4 to 5 hours, a little water being admitted from time to time, but no current being allowed to pass through, as in the washing engine.

The softest and fairest water should be selected for this purpose; and it should be administered in nicely regulated quantities, so as to produce a proper spissitude of stuff for making paper.

For printing paper, the *sizing* is given in the beating engine, towards the end of its operation. The size is formed of alum in fine powder, ground up with oil; of which mixture about a pint and a half are thrown into the engine at intervals, during the last half-hour's beating. Sometimes a little indigo blue or smalt is also added, when a peculiar bloom colour is desired. The pulp is now run off into the stuff chest, where the different kinds are mixed; whence it is taken out as wanted. The chest is usually a rectangular vessel of stone or wood lined with lead, capable of containing 300 cubic feet at least, or 3 engines full of stuff. Many paper-makers prefer round chests, as they admit of rotatory agitators.

When the paper is made in single sheets, by hand labour, as in the older establishments, a small quantity of the stuff is transferred to the working-vat by means of a pipe, and there diluted properly with water. This vat is a vessel of stone or wood, about 5 feet square, and 4 deep, with sides somewhat slanting. Along the top of the vat a board is laid, with copper fillets fastened lengthwise upon it, to make the mould slide more easily along. This board is called the bridge. The maker stands on one side; and has to his left hand a smaller board, one end of which is made fast to the bridge, while the other rests on the side of the vat. In the bridge opposite to this, a nearly upright piece of wood, called the *ass*, is fastened. In the vat there is a copper, which communicates with a steam pipe to keep it hot; there is also an agitator, to maintain the stuff in a uniform consistence.

The moulds consist of frames of wood, neatly joined at the corners, with wooden bars running across, about an inch and a half apart. Across these, in the length of the moulds, the wires run, from fifteen to twenty per inch. A strong raised wire is laid along each of the cross bars, to which the other wires are fastened; this gives the laid paper its ribbed appearance.

The water-mark is made by sewing a raised piece of wire in the form of letters, or any figured device, upon the wires of the mould, which makes the paper thinner in these places. The frame-work of a *wove* mould is nearly the same; but instead of sewing on separate wires, the frame is covered with fine wire cloth, containing from 48 to 64 meshes per inch square. Upon both moulds a *deckel*, or movable raised edge-frame, is used; which must fit very neatly, otherwise the edges of the paper will be rough.

A pair of moulds being laid upon the bridge, the workman puts on the *deckel*, brings the mould into a vertical position, dips it about half way down into the stuff before him, then turning it into a horizontal position, covers the mould with the stuff and shakes it gently. This is a very delicate operation; for if the mould be not held perfectly level, one part of the sheet will be thicker than another. The sheet thus formed has, however, no coherence; so that by turning the mould, and dipping the wire cloth surface in the vat, it is again reduced to pulp if necessary. He now pushes the mould along the small board to the left, and removes the *deckel*. Here another workman called the *coucher* receives it, and places it at rest upon the *ass*, to drain off some of the water. Meanwhile the *vat-man* puts the *deckel* upon the other mould, and makes another sheet. The *coucher* stands to the left side of the vat, with his face towards the *vat-man* or maker, on his right is the press furnished with felt cloths, or porous flannels; a three-inch-thick plank lies before him on the ground. On this he lays a cushion of felts, and on this another felt; he then turns the paper wire mould, and presses it upon the felt, where the sheet remains. He now returns the mould by pushing it along the bridge. The maker has by this time another sheet ready for the *coucher*; which, like the preceding, is laid upon the *ass*, and then couched or inverted upon another felt, laid down for the purpose.

In this way, felts and paper are alternately stratified, till a heap of six or eight quires is formed, which is from 15 to 18 inches high. This mass is drawn into the press, and exposed to a force of 100 tons or upwards. After it is sufficiently compressed, the machine is relaxed, and the elasticity of the flannel makes the rammer descend (if a hydraulic press be used) with considerable rapidity. The felts are then drawn out on the other side by an operative called a *layer*, who places each felt in succession upon one board, and each sheet of paper upon another. The *coucher* takes immediate possession of the felts for his further operations.

Two men at a vat, and a boy as a layer or lifter, can make about 6 or 8 reams in 10 hours. In the evening the whole paper made during the day, is put into another press, and subjected to moderate compression, in order to get quit of the mark of the felt, and more of the water. Next day it is all separated, a process called parting, and being again pressed, is carried into the loft. Fine papers are often twice parted and pressed, in order to give them a proper surface.

The next operation is the drying, which is performed in the following way. Posts

about 10 or 12 feet high are erected at the distance of ten feet from each other, and pierced with holes six inches apart; two spars with ropes stretched between them, at the distance of 5 inches from one another, called a treble or tribble, are placed about 5 feet high between these posts, supported by pins pushed into the holes in the posts. The workman takes up 4 or 8 sheets of paper, and puts them upon a piece of wood in the form of a T; passing this T between the ropes, he shifts the sheets upon them, and proceeds thus till all the ropes are full. He then raises the treble, and puts another in its place, which he fills and raises in like manner. Nine or ten trebles are placed in every set of posts. The sides of the drying-room have proper shutters, which can be opened to any angle at pleasure.

When the paper is dry, it is taken down, and laid neatly in heaps to be sized. Size is made of pieces of skin, cut off by the curriers before tanning, or sheep's feet, or any other matter containing much gelatine. These substances are boiled in a copper to a jelly; to which, when strained, a small quantity of alum is added. The workman then takes about 4 quires of paper, spreads them out in the size properly diluted with water, taking care that they be equally moistened. This is rather a nice operation. The superfluous size is then pressed out, and the paper is parted into sheets. After being once more pressed, it is transferred to the drying-room, but must not be dried too quickly. Three days are required for this purpose. When the paper is thoroughly dry, it is carried to the finishing-house, and is again pressed pretty hard. It is then picked by women with small knives, in order to take out the knots, and separate the perfect from the imperfect sheets. It is again pressed, given to the finisher, to be counted into reams, and done up. These reams are compressed, tied up, and sent to the warehouse for sale. A good finisher can count 200 reams, or 96,000 sheets in a day.

Hot pressing is executed by placing a sheet of paper between two smoothed pasteboards, alternately, and between every 50 pasteboards a heated plate of iron, and subjecting the pile to the press. This communicates a fine smooth surface to writing-paper.

The grain of the paper is often disfigured by the felts, when they are too much used, or when the loose fibres do not cover the twisted thread. The two sides of the felt are differently raised, and that on which the fibres are longest is applied to the sheets which are laid down. As the felts have to resist the reiterated action of the press, their warp should be made stout, of long combed wool, and well twisted. The wool, however, should be of carded wool, and spun into a soft thread, so as to render the fabric spongy, and capable of imbibing much water.

This obscure and delicate process of moulding the sheets of paper by hand, has for nearly thirty years past been performed, in many manufactories, by a machine which produces it in a continuous sheet of indefinite length which is afterwards cut into suitable sizes, by the PAPER-CUTTING MACHINE.

In 1799, Louis Robert, then employed in the paper works of Essonne in France, contrived a machine to make paper of a great size, by a continuous motion, and obtained for it a patent for 15 years, with a sum of 8000 francs from the French government, as a reward for his ingenuity. The specification of this patent is published in the second volume of *Brevets d'Invention expirés*. M. Leger-Didot, then director of the said works, bought Robert's machine and patent for 25,000 francs, to be paid by instalments. Having become proprietor of this machine, which, though imperfect, contained the germ of a valuable improvement in paper-making, M. Didot came over with it to England, where he entered into several contracts for constructing and working it.

Meanwhile M. L. Didot having failed to fulfil his obligations to Robert, the latter instituted a law-suit, and recovered possession of his patent by a decision dated 23d June, 1810. Didot then sent over to Paris the Repertory of Arts, for Sept. 1808, which contained the specification of the English patent, with instructions to a friend to secure the improved machines described in it, by a French patent. The patent was obtained, but became inoperative in consequence of M. L. Didot failing to return to France, as he had promised, so as to mount the patent machine within the two years required by the French patent law. It was not till 1815, that M. Calla, machine-maker at Paris, constructed the paper apparatus known in England by the name of Fourdrinier's, and which, on the authority of the *Dictionnaire Technologique*, was very imperfect in comparison of an English-made machine imported about that time into France. *La construction de ces machines, qui n'offre pourtant rien de difficile, est restée jusqu'à ce jour exclusivement dans les mains des Anglais*, is the painful acknowledgment made in 1829, for his countrymen, by the author of the elaborate article *Papeterie* in that national work. If there be nothing difficult in the construction of these machines, the French mechanicians ought to be ashamed of forcing their countrymen to seek the sole supply of them in England; for the principal paper works in France, as those of MM. Canson, Montgolfier, Thomas Varenne, Firmin Didot, Dolcambre, De Maupeou, &c., are mounted with English-made machines.

The following, for example, are a few of the paper-mills in France which are mounted with the self-acting machines of Messrs. Bryan Donkin & Co. :—

Messrs. Canson, at Annonay.

M. de la Place, at Jean d'Heures, Bar-le-duc.

Société anonyme, at Sainte Marie, under M. Delatouche.

Echarcon près Mennecey, (Seine et Oise).

Firmin Didot, Mesnil sur l'Estrée.

M. F. M. Montgolfier, à Annonay.

Muller, Bouchard, Ondin and Co's., at Gueures, near Dieppe.

MM. Richard et Comp. à Plainfoing.

M. Callot-Bellisle; Vieuse et Chantoiseau.

M. Bechétaile, near St. Etienne, at Bourg Argental.

It deserves particularly to be remarked, to the honour of English mechanism, that the proprietors of the first five of the above works received gold medals at the last exposition of their papers at the Louvre, and all the rest received medals either of silver or bronze.*

The following is a true narrative of the rise and progress of the paper automaton.

M. Leger Didot, accompanied by Mr. John Gamble, an Englishman who had resided for several years in Paris, obtained permission from the French government, in 1800, to carry over the small working model of Robert's continuous machine, with the view of getting the benefit of English capital and mechanical skill to bring it into an operative state upon the great scale. Fortunately for the vigorous development of this embryo project, which had proved an abortion in France, they addressed themselves on the one hand, to a mercantile firm equally opulent and public spirited, and on the other, to engineers distinguished for persevering energy and mechanical resource. A first patent was granted to Mr. Gamble on the 20th of April 1801, and a second, for certain improvements upon the former, on the 7th of June 1803. In January 1804, Mr. Gamble, for certain considerations, assigned these two patents to Messrs. Henry and Sealy Fourdrinier, the house above alluded to, who were at that period, and for several years afterwards, the most considerable stationers and paper-makers in Great Britain. By an act of parliament passed on the 4th of August 1807, Mr. Gamble's privilege of 14 years from April 1801, was prolonged to 15 years after the date of the act, being an extension of about 7 years upon the original patent.

The proprietors showed good reasons, in the enormous expense of their experiments, and the national importance of the object, why the patent should have been extended 14 years from the latter date, and would have obtained justice from parliament in this respect, but for an unworthy artifice of Lord Lauderdale in the House of Lords. "He, and he only, was the person who took the objection," and, by introducing a regulation in a standing order of the House of Lords, that none but the original inventor should have an extension, though Mr. H. Fourdrinier was the inventor substantially of the operative machine, he defeated the honourable intentions of his brother peers, whose committee said, "We will give seven years, and Mr. Fourdrinier may apply again, if it should turn out that the seven years that we propose to give to Mr. Fourdrinier should not give sufficient time to afford any chance of his receiving any remuneration for the expense that he has incurred in introducing this invention." The bill passed in the House of Commons for 14 years, but it was limited by this *ruse* of Lord Lauderdale to 7, "who put the standing order upon the books (of the upper house) which prevented Messrs. Fourdrinier from having any benefit from the invention."†

In February 1808, Mr. Gamble, after losing both his time and money savings during eight years of irksome diligence, assigned over to Messrs. Fourdrinier the whole right of his share in the patent to which he was entitled under the act of parliament.

Dartford in Kent, which had been long conspicuous as the seat of a good manufactory of paper and paper moulds, was selected by the proprietors of the patent as the fittest place for realizing their plans; and happily for them it possessed, in Mr. Hall's engineering establishment, every tool requisite for constructing the novel automaton, and in his assistant Mr. Bryan Donkin, a young and zealous mechanist, who, combining precision of workmanship with fertility of invention, could turn his local advantages to the best account. To this gentleman, aided by the generous confidence of Messrs. Fourdrinier, the glory of rearing to a stately manhood the helpless bantling of M. L. Didot is entirely due. In 1808, after nearly three years of intense application, he produced a self-acting machine for making an endless web of paper, which was erected at St. Neot's, under the superintendence of Mr. Gamble, and performed in such a manner as to surprise every beholder.

Since that important era Mr. Donkin has steadily devoted his whole mind and means

* Rapport de Jury Central, par M. Le Baron Charles Dupin, vol. II. p. 278; Paris, 1836.

† See this shabby piece of diplomacy unravelled in the Minutes of Evidence taken before the Select Committee of the House of Commons on Fourdrinier's patent; May, 1837.

to the progressive improvement of this admirable apparatus; and has, by the unflinching regularity, precision, promptitude, and productiveness of its work, earned for himself a place along with Watt, Wedgwood, and Arkwright, in the temple of mechanical fame.

"*La France*," says a late official eulogist of her arts, and interpreter of her sentiments, "ne craint plus la rivalité des autres peuples pour la fabrication des divers genres de papiers et de cartons."* After this boast, one would not expect to hear him immediately confess that in 1823 his country possessed only one manufactory of the *papier continu*, containing one of the Fourdrinier machines made at London by Mr. Donkin, for M. Canson, at Vidalon-les-Annonay; that in 1827 there were only 4 of these machines in France, and that in 1834 there were not many more than a dozen. He justly observes, that "this mode being more economical, more rapid, and more powerful, will become henceforth the only one which can be practised without loss. Then will disappear the antient system of hand-work, which likewise involved the inconveniences, we may say dangers, resulting from combinations among the operatives. The machine-made papers possess many advantages: they can receive, so to speak, unlimited dimensions; they preserve a perfectly uniform thickness throughout all their length; they may be fabricated in every season of the year; nor do they require to be sorted, trimmed, and hung up in the drying-house, operations which occasioned great waste, amounting to no less than one defective sheet out of every five. The continuous paper at one time retained the impression of the wire-wove web on its under side; a defect from which it has been freed by a pressure apparatus of Mr. Donkin, recently imported from England by M. Delatouche."

It appears from documents presented to a committee of the House of Lords in 1807, that the Messrs. Fourdrinier had, by that time, withdrawn from their stationery business the large sum of 60,000*l.*, to further the object of their patent; so many difficulties did they encounter in bringing the machinery to its then comparatively complete state, and so little encouragement or support did they receive from the paper manufacturers throughout the kingdom.

The patentees laid a statement before the public in 1806, containing the following comparative estimate of the expense attending seven vats, and that attending a machine employed upon paper sized in the engine, performing the same quantity of work as seven vats, at the rate of 12 hours daily.

A MACHINE.

| | Day. | | Week. | | Month. | | Year. | | | | |
|--|-----------|-----------|----------|-----------|----------|-----------|----------|-----------|------------|--------------|-----------|
| | <i>s.</i> | <i>d.</i> | <i>£</i> | <i>s.</i> | <i>£</i> | <i>s.</i> | <i>£</i> | <i>s.</i> | <i>d.</i> | | |
| 2 Journeymen - - - - | 3 | 6 | 2 | 2 | 0 | 8 | 8 | 0 | 109 | 4 | 0 |
| 2 Ditto - - - - | 2 | 6 | 1 | 10 | 0 | 6 | 0 | 0 | 78 | 0 | 0 |
| 2 Finishers - - - - | 3 | 6 | 2 | 2 | 0 | 8 | 8 | 0 | 109 | 4 | 0 |
| 2 Dry workers - - - - | 3 | 6 | 2 | 2 | 0 | 8 | 8 | 0 | 109 | 4 | 0 |
| Parters (none) - - - - | | | | | | | | | | | |
| Fire (none) - - - - | | | | | | | | | | | |
| Felting - - - - | | | | | | | | | 24 | 0 | 0 |
| Washing, ditto - - - - | | | | | | | | | 5 | 0 | 0 |
| Wire - - - - | | | | | | | | | 200 | 0 | 0 |
| 1 Man, to keep in repair the mill } and machine - - - - } | | | | | | | | | 100 | 0 | 0 |
| Total 9 | | | 7 | 16 | 0 | 31 | 4 | 0 | 734 | 12 | 0 |
| | | | | | | | | | <i>£</i> | <i>s.</i> | <i>d.</i> |
| Expense of 7 vats per annum (see next page), is - - - | | | | | | | | | 2,604 | 12 | 0 |
| A machine doing 7 vats' work, is, per annum - - - | | | | | | | | | 734 | 12 | 0 |
| | | | | | | | | | £ | 1,870 | 0 |
| Balance saved by the machine per annum - - - | | | | | | | | | | | |

N. B. — There are other advantages, to the amount of full 400*l.* per annum, of which manufacturers are well aware, although not taken into this calculation.

* Rapport de Jury Central, sur les Produits de l'Industrie Française exposé en 1834, par Le Baron Charles Dupin, Membre de l'Institut, Rapporteur-général et Vice Président du Jury Central; II. 273.

SEVEN VATS.

| | Day. | | Week. | | Month. | | Year. | | | | |
|--|------|----|-----------|-----------|----------|------------|----------|----------|--------------|----------|----------|
| | s. | d. | £ | s. d. | £ | s. d. | £ | s. d. | | | |
| 7 Vatmen, at - - - | 3 | 3 | 6 | 16 | 6 | 27 | 6 | 0 | 354 | 18 | 0 |
| 7 Couchers - - - | 3 | 1 | 6 | 9 | 6 | 25 | 18 | 0 | 336 | 14 | 0 |
| 7 Layers - - - | 3 | 1 | 6 | 9 | 6 | 25 | 18 | 0 | 336 | 14 | 0 |
| 3 Finishers - - - | 4 | 0 | 3 | 12 | 0 | 14 | 8 | 0 | 187 | 4 | 0 |
| 6 Dry workers - - - | 3 | 1 | 5 | 11 | 0 | 22 | 4 | 0 | 288 | 12 | 0 |
| 3 Men to go to press, &c. - | 2 | 6 | 2 | 5 | 0 | 9 | 0 | 0 | 117 | 0 | 0 |
| 7 Parters (women) - - - | 1 | 4 | 2 | 16 | 0 | 11 | 4 | 0 | 145 | 12 | 0 |
| Fire - - - | | | 7 | 0 | 0 | 28 | 0 | 0 | 364 | 0 | 0 |
| Felting - - - | | | | | | | | | 140 | 0 | 0 |
| Washing ditto, oil, soap, fire, &c. | | | 1 | 11 | 6 | 6 | 6 | 0 | 81 | 18 | 0 |
| Moulds - - - | | | | | | | | | 140 | 0 | 0 |
| 1 Man, and expenses of repairing, in keeping in order 7 vats, vat-presses, &c. } | | | | | | | | | 112 | 0 | 0 |
| Total 41 persons. | | | 42 | 11 | 0 | 170 | 4 | 0 | 2,604 | 0 | 0 |

In the same statement, it was shown that the expense of making paper by hand is 16s. per cwt., whereas by their machine it is only 3s. 9d.; so that upon 432,000 cwts. the quantity annually made in Great Britain and Ireland (as founded upon the fact that one vat can make 480 cwts. of paper, and that there were 900 vats in the kingdom), the annual saving by the machine would be 264,600L., or 345,600L. — 81,000L.

In a second statement laid before the public in 1807, the patentees observe that their recently improved machine, from its greater simplicity, may be erected at a considerably reduced expense. "Mr. Donkin, the engineer, will engage to furnish machines of the dimensions specified below, with all the present improvements, at the prices specified below.

| | Inches. | If driven by straps. | £ |
|---------------------|---------|----------------------|-------|
| or 4 vats - - - - | 30 | between the deckles | 715 |
| 6 ditto - - - - | 40 | ditto ditto | 845 |
| 8 ditto - - - - | 44 | ditto ditto | 940 |
| 12 ditto - - - - | 54 | ditto ditto | 995 |
| | | If driven by wheels. | |
| 3 or 4 vats - - - - | 30 | between the deckles | 750 |
| 6 ditto - - - - | 40 | ditto ditto | 880 |
| 8 ditto - - - - | 44 | ditto ditto | 980 |
| 12 ditto - - - - | 54 | ditto ditto | 1,040 |

"Instead of 5 men, formerly employed upon 1 machine, 3 are now (in 1813) fully sufficient, without requiring that degree of attention and skill which were formerly indispensable.

"In 1806 the machine was capable of doing the work of 6 vats in twelve hours; it is, however, now capable of doing double that quantity, at one-fourth of the expense. For by the various improvements enumerated above, the consumption of wire is reduced nearly one-half, and lasts above double the time; the quantity of paper produced is doubled; and, taking into consideration the work which is now performed by the men over and above their immediate attendance upon the machine, it may be fairly stated, that the number of men is reduced to one-half; consequently the expense of wire and labour is reduced to one-fourth of what it was.

"The other advantages incidental to the nature of the process of making paper by this machine, may be classed in the following order:—

"1st. That the paper is much superior in strength, firmness, and appearance, to any which can be made by hand of the same material.

"2d. It requires less drying, less pressing and parting, and consequently comes sooner to market; for it receives a much harder pressure from the machine than can possibly be given by any vat press, and is therefore not only drier, but, on account of the closeness and firmness of texture, even the moisture which remains is far sooner evaporated, on exposure to the air, than it would be from the more spongy or bibulous paper made by hand.

"The superior pressure, and the circumstance of one side of the paper passing under the polished surface of one of the pressing rollers, contribute to that smoothness which in hand-made papers can only be obtained by repeated parting and pressing; consequently a great part of the time necessarily spent in these operations is saved, and the paper sooner finished and ready for market.

"3dly. The quantity of broken paper and retree is almost nothing compared with what is made at the vats.

"4th. The machine makes paper with cold water.

"5th. It is durable, and little subject to be out of repair. The machine at Two Waters, in Hertfordshire, for the last three years, has not cost 10*l.* a year in repairs.

"6th. As paper mills are almost universally wrought by streams, which vary considerably in their power from time to time, there will result from this circumstance a very important advantage in the adoption of the machine. The common paper mill being limited by its number of vats, no advantage can be taken of the frequent accessions of power which generally happen in the course of the year; but, on the contrary, as scarcely any mills are capable of preparing stuff for twelve vats, every accession of power to the mill, where a machine is employed, will increase its produce without any additional expense.

"7th. The manufacturer can suspend or resume his work at pleasure; and he is besides effectually relieved from the perplexing difficulties and loss consequent upon the perpetual combinations for the increase of wages."

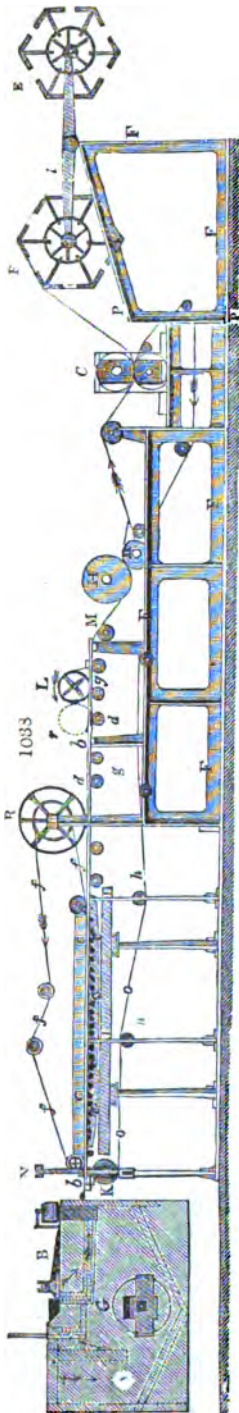
It is a lamentable fact, that the attention required to mature this valuable invention, and the large capital which it absorbed, led ultimately to the bankruptcy of this opulent and public-spirited company; after which disaster no patent dues were collected, though twelve suits in Chancery were instituted; these being mostly unsuccessful, on account of some paltry technical objections made to their well-specified patent, by that unscientific judge Lord Tenterden. The piratical tricks practised by many considerable paper-makers against the patentees are humiliating to human nature in a civilized and *voilà* Christian community. Many of them have owned, since the bankruptcy of the house removed the fear of prosecution, that they owed them from 2000*l.* to 3000*l.* apiece.

Nothing can place the advantage of the Fourdrinier machine in a stronger point of view, than the fact of there being 280 of them now at work in the United Kingdom, making collectively 1600 miles of paper, of from 4 to 5 feet broad, every day; that they have lowered the price of paper 50 per cent., and that they have increased the revenue, directly and indirectly, by a sum of probably 400,000*l.* per annum. The tissue paper made by the machine is particularly useful for communicating engraved impressions to pottery ware; before the introduction of which there was but a miserable substitute. Messrs. R. and J. Clewes, of Cobridge potteries, in a letter to Messrs. Fourdrinier, state, "that had not an improvement taken place in the manufacture of paper, the new style of engraving would have been of no use, as the paper previously used was of too coarse a nature to draw from the fair engravings any thing like a clear or perfect impression; and the Staffordshire potteries, in our opinion, as well as the public at large, are deeply indebted to you for the astonishing improvement that has recently taken place, both as regards china and earthenware, more particularly the latter." The following rates of prices justify the above statement: —

| | 1814. | 1822. | 1833. |
|-----------------------------|---------------------|---------------------|---------------------|
| | <i>s.</i> <i>d.</i> | <i>s.</i> <i>d.</i> | <i>s.</i> <i>d.</i> |
| Demy pottery tissue - - - - | 12 0 | 9 6 | 7 0 |
| Royal - - - - | 16 3 | 12 0 | 8 9 |

"We have adopted a new mode of printing on china and earthenware, which, but for your improved system of making tissue paper, must have utterly failed; our patent machine requiring the paper in such lengths as were impossible to make on the old plan. On referring to our present stock, we find we have one sheet of your paper more than 1200 yards long. Signed, Machin and Potts; Burslem, February 25th, 1834."

I have had the pleasure of visiting more than once the mechanical workshops of Messrs. Bryan Donkin and Co. in Bermondsey, and have never witnessed a more admirable assortment of exquisite and expensive tools, each adapted to perform its part with despatch and mathematical exactness, though I have seen probably the best machine factories of this country and the Continent. The man of science will appreciate this statement, and may perhaps be surprised to learn that the grand mural circle of 7 feet diameter, made by Troughton, for the Royal Observatory of Greenwich, was turned with final truth upon a noble lathe in the said establishment. It has supplied no fewer than 133 complete automatic paper machines, each of a value of from 1200*l.* to 2000*l.*, to different manufactories, not only in the United Kingdom, but in all parts of the civilized world; as mentioned in the second paragraph of the present article. Each



machine is capable of making, under the impulsion of any prime mover, all unwatched by a human eye, and unguided by a human hand, from 20 to 50 feet in length, by 5 feet broad, of most equable paper in one minute. Of paper of average thickness, it turns off 30 feet.

Fig. 1038. is an upright longitudinal section, representing the machine in its most complete state, including the drying steam cylinders, and the compound channelled rollers of Mr. Wilks, subsequently to be described in detail. The figure in the upper line shows it all in train, when the paper is to be wound up wet upon the reels *x, x*, which being movable round the centre *l* of a swing-bar, are presented empty, time about, to receive the tender web. The figure in the under line contains the steam or drying cylinders; the points *o, o*, of whose frame, replace, at the points *r, r*, the wet-reel frame, *r, r, r*. *A* is the vat, or receiver of pulp from the stuff-chest.

B is the knot strainer of Ibotson (p 341.), to clear the pulp before passing on to the wire.

C is the hog, or agitator in the vat. The arrows show the course of the currents of the pulp in the vat.

D is the apron, or receiver of the water and pulp which escape through the endless wire, and which are returned by a scoop-wheel into the vat.

E is the copper lip of the vat, over which the pulp flows to the endless wire, on a leathern apron extending from this lip to about 9 inches over the wire, to support the pulp and prevent its escaping.

G, G are the bars which bear up the small tube rollers that support the wire.

H, H are ruler bars, to support the copper rollers over which the wire revolves.

I is the breast roller, round which the endless wire turns.

K is the point where the shaking motion is given to the machine.

M is the guide roller, having its pivots movable laterally to adjust the wire and keep it parallel.

N is the pulp roller, or "dandy," to press out water, and to set the paper. *O*, is the place of the second, when it is used.

P is the first or wet press, or couching rollers; the wire leaves the paper here, which latter is couched upon the endless felt *p*; and the endless wire *o* returns, passing round the lower couch roller. By Mr. Donkin's happy invention of placing these rollers obliquely, the water runs freely away, which it did not do when their axes were in a vertical line.

R, R are the deckles, which form the edges of the sheet of paper, and prevent the pulp passing away laterally. They regulate the width of the endless sheet.

S, S are the revolving deckle straps.

T is the deckle guide, or driving-pulley.

U, U are tube rollers, over which the wire passes, which do not partake of the shaking motion; and,

A, A are movable rollers for stretching the wire, or brass carriages for keeping the rollers *g, g* in a proper position.

c is the second press, or dry press, to expel the water in a cold state.

x, x, &c., in the view of the lower line, are the steam cylinders for drying the endless sheet.

i, i are rollers to convey the paper.

j, j are rollers to conduct the felt; which serves to support the paper, and prevent it wrinkling or becoming cockled.

D, D are the hexagonal expanding reels for the steam-dried paper web, one only being used at a time, and made to suit different sizes of sheets. *l* is their swing fulcrum.

V, V, V, is the frame of the machine.

The deckle straps are worthy of particular notice in this beautiful machine. They are composed of many layers of cotton tape, each one inch broad, and together one half-inch thick, cemented with caoutchouc, so as to be at once perfectly flexible and water-tight.

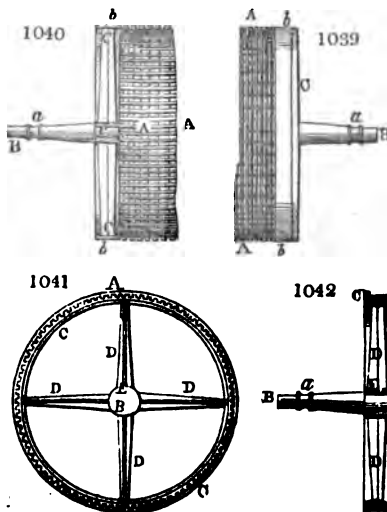
The upper end of each of the two carriages of the roller *L* is of a forked shape, and the pivots of the roller are made to turn in the cleft of the forked carriages in such a manner, that the roller may be prevented from having any lateral motion, while it possesses a free vibratory motion upwards and downwards; the whole weight of the roller *L* being borne by the endless web of woven wire.

The greatest difficulty formerly experienced in the paper manufacture upon the continuous system of Fourdrinier, was to remove the moisture from the pulp, and condense it with sufficient rapidity, so as to prevent its becoming what is called *water-galled*, and to permit the web to proceed directly to the drying cylinders. Hitherto no invention has answered so well in practice to remove this difficulty as the channelled and perforated pulp rollers or dandies of Mr. John Wilks, the ingenious partner of Mr. Donkin; for which a patent was obtained in 1830. Suppose one of these rollers (see *L*, *fig.* 1038., and *M, M*, *fig.* 1043.,) is required for a machine which is to make paper 54 inches wide, it must be about 60 inches long, so that its extremities (see *figs.* 1039 and 1040.) may extend over or beyond each edge of the sheet of paper upon which it is laid. Its diameter may be 7 inches. About 8 grooves, each 1-16th of an inch wide, are made in every inch of the tube; and they are cut to half the thickness of the copper, with a rectangularly shaped tool. A succession of ribs and grooves are thus formed throughout the whole length of the tube. A similar succession is then made across the former, but of 24 in the inch, and on the opposite surface of the metal, which by a peculiar mode of management had been prepared for that purpose. As the latter grooves are cut as deep as the former, those on the inside meet those on the outside, crossing each other at right angles, and thereby producing so many square holes; leaving a series of straight copper ribs on the interior surface of the said tube, traversed by another series of ribs coiled round them on the outside, forming a cylindrical sieve made of one piece of metal. The rough edges of all the ribs must be rounded off with a smooth file into a semicircular form. *Figs.* 1039, and 1040., *A, A*, are portions of the ribbed copper tube. *Fig.* 1039. shows the exterior, and *fig.* 1040. the interior surface; *b, b* and *b, b* show the plain part at each of the ends, where it is made fast to the brass rings by rivets or screws; *c, c* are the rings with arms, and a centre piece in each, for fixing the iron pivot or shaft *B*; one such pivot is fixed by riveting it in each of the centre pieces of the rings, as shown at *c*, *fig.* 1040.; so that both the said pieces shall be concentric with the rings, and have one common axis with each other, and with the roller.

At *a, a*, a groove is turned in each of the pivots, for the purpose of suspending a weight by a hook, in order to increase the pressure upon the paper, whenever it may be found necessary.

Fig. 1041. is an end view, showing the copper tube and its internal ribs *A, A*; the brass rings *c, c*; arm *D, D, D*; centre piece *E*, and pivot *B*. *Fig.* 1042. is a section of the said ring, with the arms, &c.

The roller is shown at *L*, *fig.* 1038., as lying upon the surface of the wire-web.



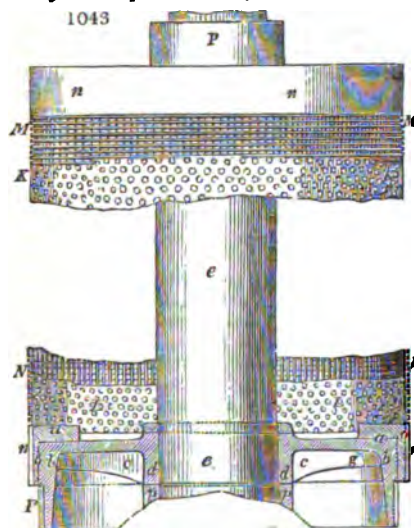
The relative position of that perforated roller, and the little roller *b*, over which it lies, is such that the axis of *l* is a little to one side of the axis of *b*, and not in the same vertical plane, the latter being about an inch nearer the vat end. Hence, whenever the wire-web is set in progressive motion, it will cause the roller *l* to revolve upon its surface; and as the paper is progressively made, it will pass onwards with the web under the surface of the roller. Thus the pulpy layer of paper is condensed by compression under the ribbed roller; while it transmits its moisture through the perforations, it becomes sufficiently compact to endure the action of the wet press rollers *h*, *s*, and also acquires the appearance of parallel lines, as if made by hand in a laid mould.

Mr. Wilks occasionally employs a second perforated roller in the same paper machine, which is then placed at the dotted lines *i*, *i*.

The patentee has described in the same specification a most ingenious modification of the said roller, by which he can exhaust the air from a hollowed portion of its periphery, and cause the paper in its passage over the roller to undergo the sucking operation of the partial void, so as to be remarkably condensed; but he has not been called upon to apply this second invention, in consequence of the perfect success which he has experienced in the working of the first.

The following is a more detailed illustration of Mr. Wilks' improved roller.

Fig. 1043. represents two parts of his double-cased exhausting cylinder.



This consists of two copper tubes, one nicely lining the other; the inner being punched full of round holes, as at *k, k*, where that tube is shown uncovered: a portion of the inner surface of the same tube is shown at *l, l*. In this figure also, two portions of the outer tube are shown at *m, m*, and *n, n*; the former being an external, and the latter an internal view. Here we see that the external tube is the ribbed perforated one already described; the holes in the inner tube being made in rows to correspond with the grooves in the outer. The holes are so distributed that every hole in one row shall be opposite to the middle of the space left between two holes in the next row, as will appear from inspection of the figure. The diameter of each of the punched holes somewhat exceeds the width of each rib in the inside of the outer cylinder, and every inside groove of this tube coincides with a row of holes in the former, which construction permits the free transudation or percolation of the water out of the pulp.

At each end of this double-case cylinder, a part is left at *n, n*, plain without, and grooved merely in the inside of the outer tube. The smooth surface allows the brass ends to be securely fixed; the outer edge of the brass ring fits tight into the inside of the end of the cylinders.

On the inside of each of these rings there are four pieces which project towards the centre or axis of the cylinder; two of which pieces are shown at *a, a*, fig. 1043, in section. *b, b*, is a brass ring with four arms *c, c, c, c*, and a boss or centre piece *d, d*. The outer edge of the last-mentioned ring is also turned cylindrical, and of such a diameter as to fit the interior of the former ring *o, o*. The two rings are securely held together by four screws. *e, e* is the hollow iron axle or shaft upon which the cylinder revolves. Its outside is made truly cylindrical, so as to fit the circular holes in the bosses *d, d*, of the rings and arms at each end of the cylinder. Hence, if the hollow shaft be so fixed that it will not turn, the perforated cylinder is capable of having a rotatory motion given to it round that shaft. This motion is had recourse to, when the vacuum apparatus is employed. But otherwise the cylinder is made fast to the hollow axle by means of two screw clamps. To one end of the cylinder, as at *p*, a toothed wheel is attached, for communicating a rotatory motion to it, so that its surface motion shall be the same as that of the paper web; otherwise a rubbing motion might ensue, which would wear and injure both.

The paper stuff or pulp is allowed to flow from the vat *a*, fig. 1038., on to the surface of the endless wire-web, as this is moving along. The lines *o, o*, fig. 1038. show the course of

the motion of the web, which operates as a sieve, separating to a certain degree the water from the pulp, yet leaving the latter in a wet state till it arrives at the first pair of pressing rollers *n, n*, between which the web with its sheet of paper is squeezed. Thick paper, in passing through these rollers, was formerly often injured by becoming water-galled, from the greater retention of water in certain places than in others. But Messrs. Donkin's cylinder, as above described, has facilitated vastly the discharge of the water, and enabled the manufacturer to turn off a perfectly uniform smooth paper.

In *fig. 1038.*, immediately below the perforated cylinder, there is a wooden water-trough. Along one side of the trough a copper pipe is laid, of the same length as the cylinder, and parallel to it; the distance between them being about one fourth of an inch. The side of the pipe facing the cylinder is perforated with a line of small holes, which transmit a great many jets of water against the surface of the cylinder, in order to wash it and keep it clean during the whole continuance of the process.

The principle adopted by John Dickinson, Esq., of Nash Mill, for making paper, is different from that of Fourdrinier. It consists in causing a polished hollow brass cylinder, perforated with holes or slits, and covered with wire cloth, to revolve over and just in contact with the prepared pulp; so that by connecting the cylinder with a vessel exhausted of its air, the film of pulp, which adheres to the cylinder during its rotation, becomes gently pressed, whereby the paper is supposed to be rendered drier, and of more uniform thickness, than upon the horizontal hand moulds, or travelling wire cloth of Fourdrinier. When subjected merely to agitation, the water is sucked inwards through the cylindrical cage, leaving the textile filaments so completely interwoven as, if felted among each other, that they will not separate without breaking, and, when dry, they will form a sheet of paper of a strength and quality relative to the nature and preparation of the pulp. The roll of paper thus formed upon the hollow cylinder is turned off continuously upon a second solid one covered with felt, upon which it is condensed by the pressure of a third revolving cylinder, and is thence delivered to the drying rollers.

Such is the general plan of Mr. Dickinson's paper machines, into which he has introduced numerous improvements since its invention in 1809, many of them secured by patent right; whereby he has been enabled to make papers of first-rate quality, more particularly for the printing-press. See *infra*.

In July 1830, Mr. Ibotson of Poyle, paper manufacturer, obtained a patent, see *n, fig. 1038.* which has proved very successful, for a peculiar construction of a sieve or strainer. Instead of wire meshes, he uses a series of bars of gun-metal, laid in the bottom of a box, very closely together, so that the upper surfaces or the flat sides may be in the same plane, the edge of each bar being parallel with its neighbour, leaving parallel slits between them of from about 1-70th to 1-100th of an inch in width, according to the fineness or coarseness of the paper-stuff to be strained. As this stuff is known to consist of an assemblage of very fine flexible fibres of hemp, flax, cotton, &c., mixed with water, and as, even in the pulp of which the best paper is made, the length of the said fibres considerably exceeds the diameter of the meshes of which common strainers are formed, consequently the longest and most useful fibres were formerly lost to the paper manufacturer. Mr. Ibotson's improved sieve is employed to strain the paper-stuff previously to its being used in the machine above described. (see its place at *n* in the *vat*.) When the strainer is at work, a quick vertical and lateral jogging motion is given to it, by machinery similar to the joggling-screens of corn mills.

Since the lateral shaking motion of the wire-web in the Fourdrinier machine, as originally made, was injurious to the fabric of the paper, by bringing its fibres more closely together breadthwise than lengthwise, thus tending to produce long ribs, or thick streaks in its substance, Mr. George Dickinson, of Buckland Mill, near Dover, proposed, in the specification of a patent obtained in February, 1828, to give a rapid up-and-down movement to the travelling web of pulp. He does not, however, define with much precision any proper mechanism for effecting this purpose, but claims every plan which may answer this end. He proposes generally to mount the rollers, which conduct the horizontal endless web, upon a vibrating frame. The forepart of this frame is attached to the standards of the machine, by hinge joints, and the hinder part, or that upon which the pulp is first poured out, is supported by vertical rods, connected with a crank on a shaft below. Rapid rotatory motion being given to this crank-shaft, the hinder part of the frame necessarily receives a quick up-and-down vibratory movement, which causes the water to be shaken out from the web of pulp, and thus sets the fibres of the paper with much greater equality than in the machines formerly constructed. A plan similar to this was long ago introduced into Mr. Donkin's machines, in which the vibrations were actuated in a much more mechanical way.

John Dickinson, Esq., of Nash Mill, obtained a patent in October, 1830, for a method of uniting face to face two sheets of pulp by means of machinery, in order to produce paper

of extraordinary thickness. Two vats are to be supplied with paper stuff as usual; in which two hollow barrels or drums are made to revolve upon axles driven by any first mover; an endless felt is conducted by guide rollers, and brought into contact with the drums; the first drum gives off the sheet of paper pulp from its periphery to the felt, which passing over a pressing roller, is conducted by the felt to that part of a second drum which is in contact with another pressing roller. A similar sheet of paper pulp is now given off from the second drum, and it is brought into contact with the former by the pressure of its own roller. The two sheets of paper pulp thus united are carried forward by the felt over a guide roller, and onward to a pair of pressing rollers, where by contact the moist surfaces of the pulp are made to adhere, and to constitute one double thick sheet of paper, which, after passing over the surfaces of hollow drums, heated by steam, becomes dry and compact. The rotatory movements of the two pulp-lifting drums must obviously be simultaneous, but that of the pressing rollers should be a little faster, because the sheets extend by the pressure, and they should be drawn forward as fast as they are delivered, otherwise creases would be formed. Upon this invention is founded Mr. Dickinson's ingenious method of making safety-paper for Post-office stamps, by introducing silk fibres, &c., between the two laminae.

The following contrivance of the same inventive manufacturer is a peculiarly elegant mechanical arrangement, and is likely to conduce to the perfection of machine-made paper. I have already described Mr. Ibotson's excellent plan of parallel slits, or grid-iron strainers, which has been found to form paper of superior quality, because it permits all the elongated tenacious fibres to pass, which give strength to the paper, while it intercepts the coarser knots and lumps of the paste, that were apt to spoil its surface. Mr. Turner's circular wire sieves, presently to be noticed, may do good work, but they cannot compete with Mr. Dickinson's present invention, which consists in causing the diluted paper pulp to pass between longitudinal apertures, about the hundred-and-fifteenth part of an inch wide, upon the surface of a revolving cylinder.

The pulp being diluted to a consistency suitable for the paper machine, is delivered into a vat, of which the level is regulated by a waste pipe, so as to keep it nearly full. From this vat there is no other outlet for the pulp, except through the wire-work periphery of the revolving cylinder, and thence out of each of its ends into troughs placed alongside, from which it is conducted to the machine destined to convert it into a paper web.

The revolving cylinder is constructed somewhat like a squirrel cage, of circular rods, or an endless spiral wire, strengthened by transverse metallic bars, and so formed that the spaces between the rings are sufficient to allow the slender fibres of the pulp to pass through, but are narrow enough to intercept the knots and other coarse impurities, which must of course remain, and accumulate in the vat. The spaces between the wires of the squirrel cage may vary from the interval above stated, which is intended for the finest paper, to double the distance for the coarser kinds.

It has been stated that the pulp enters the revolving cylinders solely through the intervals of the wires in the circumference of the cylinder; these wires or rods are about three-eighths of an inch broad without, and two-eighths within, so that the circular slits diverge internally. The rods are one quarter of an inch thick, and are riveted to the transverse bars in each quadrant of their revolution, as well as at their ends to the necks of the cylinder.

During the rotation of the cylinder, its interstices would soon get clogged with the pulp, were not a contrivance introduced for creating a continual vertical agitation in the inside of the cylinder. This is effected by the up-and-down motion of an interior agitator or plunger, nearly long enough to reach from the one end of the cylinder to the other, made of stout copper, and hollow, but water-tight. A metal bar passes through it, to whose projecting arm at each end a strong link is fixed; by these two links it is hung to two levers, in such a way that when the levers move up and down, they raise and depress the agitator, but they can never make it strike the sides of the cylinder. Being heavier than its own bulk of water, the agitator, after being lifted by the levers, sinks suddenly afterwards by its weight alone.

The agitator's range of up-and-down movement should be about one inch and a quarter, and the number of its vibrations about 80 or 100 per minute; the flow of the pulp through the apertures is suddenly checked in its descent, and promoted in its ascent, with the effect of counteracting obstructions between the ribs of the cylinder.

The sieve cylinder has a toothed wheel fixed upon the tubular part of one of its ends, which works between two metal flanches made fast to the wooden side of the vat, for the purpose of keeping the pulp away from the wheel; and it is made to revolve by a pinion fixed on a spindle, which going across the vat, is secured by two plummer blocks on the outside of the troughs, and has a rotatory motion given to it by an outside rigger or pulley, by means of a strap from the driving shaft, at the rate of 40 or 50 revolutions per minute. This spindle has also two double eccentrics fixed upon it, immediately

under the levers, so that in every revolution it lifts those levers twice, and at the same time lifts the agitator.

The diameter of the sieve cylinder is not very material, but 14 inches have been found a convenient size; its length must be regulated according to the magnitude of the machine which it is destined to supply with pulp. One, four feet long in the cage part, is sufficient to supply a machine of the largest size in ordinary use, viz., one capable of making paper 4 feet 6 inches wide. When the cylinder is of this length, it should have a wheel and pinion at each end.

Metal flanges are firmly fixed to the sides of the vat, with a water-tight joint, and form the bearings in which the cylinder works.

Mr. Turner of Bermondsey, paper-maker, obtained a patent in March, 1831, for a peculiar strainer, designed to arrest the lumps mixed with the finer paper pulp, whereby he can dispense with the usual vat and hog in which the pulp is agitated immediately before it is floated upon the endless wire-web of the Fourdrinier apparatus. His strainer may also be applied advantageously to hand paper machines. He constructs his sieves of a circular form, by combining any desirable number of concentric rings of metal, with small openings between them, from the 50th to the 100th part of an inch wide. In order to facilitate the passage of the fine pulp and water, the sieves receive a vibratory motion up and down, which supersedes the hog employed in other paper-making machines.

A mechanism to serve the same purpose as the preceding, in which Mr. Ibotson's plan of a parallel rod-strainer is modified, was made the subject of a patent by Mr. Henry Brewer, of Surrey Place, Southwark, in March, 1832. He constructs square boxes with gridiron bottoms, and gives a powerful up-and-down vibration in the pulp tub, by levers, rotatory shafts, and cranks.

As the contrivance is not deficient in ingenuity, and may be useful, I shall describe this mode of adapting his improved strainers to a vat in which paper is to be made by hand moulds. A hog (or churning rotator) is employed for the purpose of agitating the pulp at the bottom of the vat, in which the sieve is suspended from a crank-shaft, or in any other way, so as to receive the up-and-down vibratory motion for the purpose of straining the pulp. The pulp may be supplied from a chest, and passed through a cock into a trough, by which it is conveyed to the strainers.

A pipe from the bottom of the vat leads into a lifter-box, which is designed to convey thin pulp into the sieve, in order to dilute that which is delivered from the chest. This pipe also allows the small lumps, called rolls, to be re-sifted. The pressure of the pulp and water in the vat forces the pulp up the pipe into the lifter-box, whence it is taken by rotatory lifters, and discharged into a trough, where it runs down and mixes with the thick pulp from the chest, as before mentioned. By these means the contents of the vat are completely strained or sifted over again in the course of almost every hour.

A patent was obtained for a paper-pulp strainer by Mr. Joseph Amies, of Loose, in the county of Kent, paper manufacturer, who makes the bottoms of his improved strainers with plates of brass or other suitable metal, and forms the apertures for the fine fibres of pulp to pass through, by cutting short slits through such plates, taking care that as much metal is left between the ends of each short slit and the next following as will properly brace or stiffen the ribs of the strainer; and he prefers that the end of one slit shall be nearly opposite to the middle of the two slits next adjoining it, which is commonly called blocking the joints. This is for giving rigidity to the bottom of the strainer, and constitutes the main feature of his improvement. The bottoms of sieves previously constructed with long metallic rods, he considers to be liable to lateral vibration in use, and thus to have permitted knots and lumps to pass through their expanded intervals. This objection is not applicable to Mr. Dickinson's squirrel-cage strainer, of which the ribs may be made rigid by a sufficient number of transverse bars; nor in fact is it applicable to Mr. Ibotson's original strainer, as it is admirably constructed by Messrs. Donkin and Co. Each bar which they make being inflexible by a feathered rib, is rendered perfectly straight in its edge by grinding with emery upon a flat disc-wheel of block tin, and of invariable length, by a most ingenious method of turning each set of bars in a lathe. The bars are afterwards adjusted in the metallic sieve-frame, or chest, at any desired distance apart, from the 120th to the 60th of an inch, in such a manner as secures them from all risk of derangement by the vibratory or joggling motion in shaking the pulpy fibres through the lineal intervals between them.

Mr. James Brown, paper manufacturer, of Esk mills, near Edinburgh, obtained a patent in May, 1836, for a particular mode of applying suction to the pasty web in the Fourdrinier's machine. He places a rectangular box transversely beneath the horizontal wire cloth, without the interposition of any perforated covering, such as had been

tried in the previously constructed vacuum machines, and which he considers to have impeded their efficacy in condensing the pulp and extracting the water.

Upon this and all similar contrivances for making a partial vacuum under the pulpy paper web, it may be justly remarked, that they are more apt to injure than improve the texture of the article; since when the suction is unequally operative, it draws down not only the moisture, but many of the vegetable fibres, causing roughnesses, and even numerous small perforations in the paper.

A modification of Mr. Dickinson's cylinder-mould continuous paper machine was made the subject of a patent in Nov. 1830, by Mr. John Hall, jun., of Dartford, as communicated to him by a foreigner residing abroad. The leading feature of the invention is a mode of supplying the vat in which the wire cylinder is immersed with a copious flow of water, for the purpose of creating a considerable pressure upon the external surface of the cylinder, and thereby causing the fibres of the paper pulp to adhere to the mould.

There is a semi-cylindrical trough, in which the mould is immersed, and made to revolve by any convenient means. The pulp is transferred from the vat into that vessel at its bottom part. On the side of the drum-mould opposite to the vat, there is a cistern into which a copious flow of water is delivered, which passes thence into the semi-cylindrical trough. In the interior of the cylindrical mould, a bent or syphon tube is introduced, on the horizontal part of which tube, inside, the mould revolves. This tube is connected at the outside to a pump, by which the water is drawn from the interior of the cylindrical mould. Thus the water in the semi-cylindrical trough, on the outside of the drum, is kept at a considerably higher level than it is within; and consequently the pressure of the water, as it passes through the wire gauze, will, it is supposed, cause the fibres of the paper pulp to adhere to the circumference of the mould. The water which is withdrawn from the interior of the drum by the recurved tube, is conducted round into the cistern, where its discharge is impeded by several vertical partitions, which make the water flow in a gentle stream into the semi-cylindrical mould vat. In order to keep the pulp properly agitated in the mould vat, a segment frame, having rails extended across the vat, is moved to and fro; as the drum mould goes round, the fibres of the pulp are forced against its circumference, and as the water passes through, the fibres adhere, forming the sheet of paper, which, on arriving at a couching roller above, is taken up as usual by an endless felt, conducted away to the drying apparatus, and thence to the reel to be wound up.

The patentee claims merely the application of a pump to draw the water from the interior of the mould drum, and to throw it upon its external surface.

A rag-cutting and lacerating machine was patented by Mr. Henry Davy, of Camberwell, in September, 1833, being a communication from a foreigner residing abroad. The machine consists of an endless feeding-cloth, by which the rough rags supplied by the attendants are progressively conducted forwards to a pair of feed-rollers (see *CORTEX, spinning*), and on passing through these rollers, the rags are subjected to the operation of rotatory cutters, acting against a fixed or ledger blade, which cut and tear them to pieces. Thence the rags pass down an inclined sieve, upon which they are agitated to separate the dust. The cleaned fragments are delivered on to a horizontal screen or sorting table, to suffer examination. When picked here, they are ready for the pulp-engine. A distinct representation of this machine is given in Newton's Journal, conjoined series, vol. iv. pl. ix. fig. 1.

Mr. Jean Jacques Jequier obtained a patent in August, 1831, for a mode of making paper on the continuous machine with wire-marks. The proposed improvement consists merely in the introduction of a felt pressing roller, to act upon the paper after it has been discharged from the mould, and need not therefore be particularly described.

In August, 1830, Mr. Thomas Barratt, paper-maker, of St. Mary Cray, in the county of Kent, obtained a patent for an apparatus by which paper may be manufactured in a continuous sheet, with the water-mark and maker's name, so as to resemble in every respect paper made by hand, in moulds the size of each separate sheet. On the wire web, at equal distances apart, repetitions of the maker's name or other device is placed, according to the size of the paper when cut up into single sheets. In manufacturing such paper, the ordinary method of winding upon a reel cannot be employed; and therefore the patentee has contrived a compensating reel, whose diameter diminishes at each revolution, equal to the thickness of a sheet of paper. See Newton's Journal, C. S. vol. vii. p. 285.

For Mr. Lemuel Wellman Wright's series of improvements in the manufacture of paper, specified in his patent of November, 1834, I must refer to the above Journal, C. S., vol. viii. p. 86.

A committee of the *Société d'Encouragement*, of Paris, made researches upon the best composition for sizing paper in the vat, and gave the following recipe:—

| | | |
|-------------------------------------|---|---|
| 100 kilogrammes of dry paper stuff. | | |
| 12 | — | starch. |
| 1 | — | rosin, previously dissolved in 500 grammes of carbonate of soda. |

18 pails of water.

M. Braconnot proposed the following formula in the 23d volume of the *Annales de Chimie et de Physique*:—To 100 parts of dry stuff, properly diffused through water, add a boiling uniform solution of 8 parts of flour, with as much caustic potash as will render the liquor clear. Add to it one part of white soap previously dissolved in hot water. At the same time heat half a part of rosin with the requisite quantity of weak potash lye for dissolving the rosin; mix both solutions together, and pour into them one part of alum dissolved in a little water.

Those who colour prints, size them previously with the following composition:—4 ounces of glue, and 4 ounces of white soap dissolved in 3 English pints of hot water. When the solution is complete, 2 ounces of pounded alum must be added, and as soon as the composition is made homogeneous by stirring, it is ready for use. It is applied cold with a sponge, or rather with a flat camel's hair brush. Ackermann's liquor, as analysed by Vauquelin, may be made for sizing paper as follows:—

| | | |
|-------------------------------|---|----------------|
| 100 kilogrammes of dry stuff. | | |
| 4 | — | glue. |
| 8 | — | resinous soap. |
| 8 | — | alum. |

The soap is made from 4·8 kilos. of pounded rosin, and 2·22 crystals of carbonate of soda, dissolved in 100 litres of water. It is then boiled till the mixture becomes quite uniform; the glue previously softened by 12 hours' maceration in cold water, is to be next added; and when this is totally dissolved, the solution of alum in hot water is poured in. Three quarts of this size were introduced into the vat with the stuff, and well mixed with it. The paper manufactured with this paste seemed to be of excellent quality, and well sized.

The Chinese, in manufacturing paper, sometimes employ linen rags, as we do; at other times, the fibres of the young bamboo; of the mulberry; the envelope of the silk-worm cocoon; also a tree, unknown to our botanists, which the natives call *chu* or *ho-chu*; cotton down, and especially the cotton tree. The processes pursued in China to make paper with the inner bark of their *paper-tree* (*Broussonetia papyrifera*), or Chinese mulberry, have been described at great length in the bulletin of the Société d'Encouragement, for 1826, p. 226; but they will hardly prove serviceable to a European manufacturer. That tree has been acclimated in France.

Chinese paper is not so well made as the good paper of Europe; it is not so white, it is thinner, and more brittle, but extremely soft and silky. The longitudinal tenacity of its filaments, however, renders it fitter for the engraver than our best paper. The Chinese, after trituration, grinding, and boiling the bamboo, set the paste to ferment in a heap covered with mats. Chinese paper is readily recognised, because it is smooth on one side, and bears on the other the marks of the brush with which it is finished, upon smooth tables, in order to dry it flat. The kind employed for engravings is in sheets four feet long, and two broad. It is made of the bamboo; their myrtle-tree paper would be too strong for this purpose.

Paper, sizing of. Mr. John Dickinson obtained a patent, in 1840, for a mode of sizing paper continuously in a vessel partially exhausted of air, by unwinding a scroll of dried paper from a reel, and conducting it through heated size; then after pressing out the superfluous size, winding the paper on to another reel; in the course of which final progress it is dried by steam heat.—*Newton's Journal*, xxiii. 20.

Tracing Paper.

The best paper of this kind, sometimes superfluously called vegetable paper, is made of the refuse of the flax mills, and prepared by the engine without fermentation. It thus forms a semi-transparent paste, and affords a transparent paper. Bank-note paper is made of the same materials, but they always undergo a bleaching with chloride of lime. Great nicety is required in drying this kind of paper. For this purpose, each sheet must be put between two sheets of gray paper in the press; and this gray paper must be renewed several times, to prevent the bank-note paper from creasing.

Paper of Safety or Surety; Papier de Sureté.

This subject has occupied the attention of the French Academy for many years, in consequence of the number of frauds committed upon the stamp revenue in France. One of the best methods of making a paper which would evince whether any part of a writing traced upon it had been tampered with or discharged, is to mix in the vat

two kinds of pulp, the one perfectly white, the other dyed of any colour easily affected by chlorine, acids, and alkalis. The latter stuff being mingled with the former in any desired proportion, will furnish a material for making a paper which will contain coloured points distributed throughout all its substance, ready to show, by the changes they suffer, whether any chemical reaction has been employed.

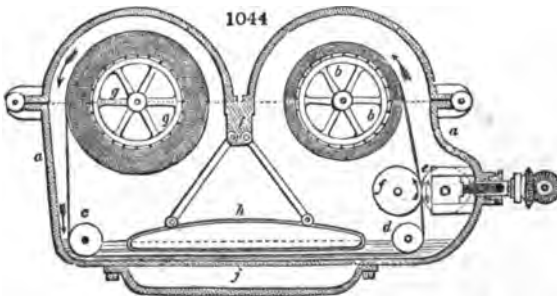
PAPER-MAKING. The construction of wire web cylinders for paper-making machines, and the combination of two such cylinders in one machine, by the use of which two distinct thicknesses of paper pulp are obtained, and applied face-wise, to form one thick sheet, were made the subject of a patent, under the name of John Donkin. Two cylinders are so placed in a vat that their circumferences are nearly in contact, and by being turned in opposite directions, they bring two sheets of paper pulp into contact, and incorporate them into one, by what is technically termed *couching*.

An extensive patent for improvements in the manufacture of paper was granted to Charles Edward Amos in 1840. These consist, first, in gradually lowering the roll of the engine in which the rags are prepared and converted into pulp; secondly, in a mode of regulating the supply of pulp to the paper-making machine, in order to produce papers of any required thickness; thirdly, in an improved sifter or strainer through which the pulp is passed for clearing it of knobs and lumps; fourthly, in certain modifications of the parts of the machine in which the pulp is deposited and moulded into continuous lengths of paper; fifthly, in an improved method of heating the cylinders of the drying apparatus; and, sixthly, in improvements of the machinery for cutting the paper into sheets of any required dimensions. The details of these ingenious contrivances, illustrated with engravings, are given in *Newton's Journal*, xx., p. 153. C. S.

Henry Crossley purposes to manufacture paper from waste tan, and spent hops— with what success I have not heard. Joseph Hughes gives a higher finish to the long web of paper by friction between two cylinders, the one of which moves much quicker than the other, both being covered with felt or not, at pleasure.

Mr. John Dickinson, the eminent paper manufacturer, obtained a patent in 1840 for a new mode of sizing paper continuously, in an air-tight vessel (partly exhausted of air), by unwinding a scroll of dried paper from a reel, and conducting it through heated size; then, after pressing out the superfluous size, winding the paper on to another reel.

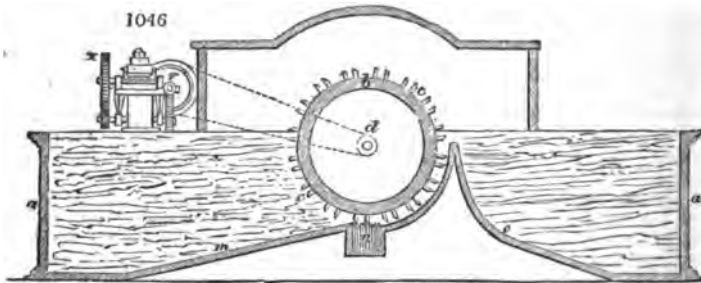
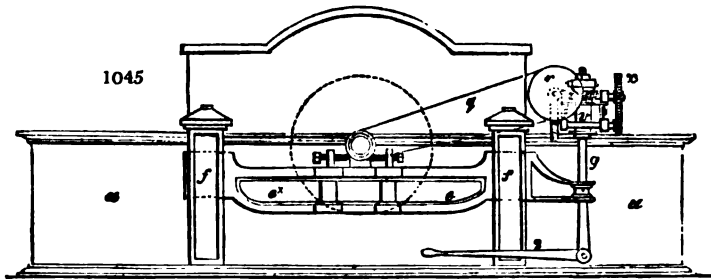
A longitudinal section of the apparatus employed for this purpose is represented *fig. 1044*; where *a* is the air-tight vessel; *b*, the reel upon which the paper to be sized is wound; whence it proceeds beneath the guide-roller *c*, and through the warm size to another guide-roller *d*. It thence ascends between the press-rolls, *e*, *f* (by whose revolution the paper is drawn from the reel *b*), and is wound upon the reel *g*. A float *h* is suspended from the cross-bar *i*, of the vessel *a*, for the purpose of diminishing the surface of size exposed to evaporation; and beneath the bottom of the vessel is an enclosed space *j*, into which steam or hot water is introduced for maintaining the temperature of the size.—*Newton's Journal*, xxiii. 20.



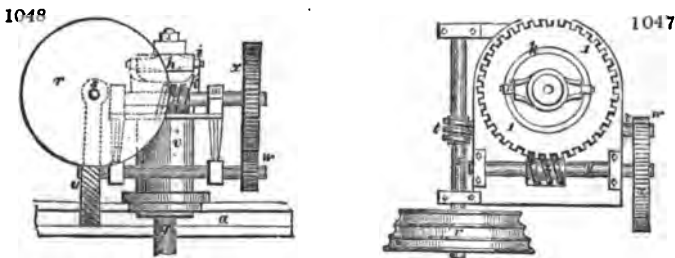
Messrs. Charles Cowan and Adam Ramage, paper makers, patented, in 1840, improved rag machinery; in which a cylindrical sieve or strainer of wire cloth, of a peculiar construction, is substituted for the ordinary strainers, by which the dirty water is separated from the pulp. They do not claim the cylindrical form of sieve, but "the adding or applying, and combining within the interior of such drum, scoops, or bucket, for the purpose of elevating the water, which has entered into it through its wire circumference, so that the water when elevated may be able to run by its own gravity out of the hollow around the central axis of the drum into any suitable shoot or trough, and escape at a level above the surface of the water and rags or material contained in the paper-machine."

Thomas Barrett claims, in his patent of 1841, "a mode of drying paper by applying streams of air to its two surfaces, as it passes over the steam cylinders, whether in the state of engine size or paperleaf, or after sizing; as also, the application of currents of air to the surfaces of paper, after sizing, in order to cool the size; as the paper is passing to the drying cylinders."

The improvement in paper making, for which T. W. Wrigley, of Bridge Hall Mills, Bury, obtained a patent in 1842, relate to the rag engine *figs.* 1045, 46, 47,



1048. *Fig.* 1045. is a side elevation; *fig.* 1046. a transverse section, taken lengthwise through nearly its middle; *fig.* 1047., a plan view of the apparatus detached upon a



larger scale; and *fig.* 1048 is an elevation. The vessel in which the rags are placed is shown at *a a*, and in about the centre of this vessel the beating or trituring roll, *b b*, is placed: it is surrounded with the blades or roll bars *c c*, *fig.* 1046. The roll is mounted upon a shaft, *d d*, one end of which is placed in a pedestal or bearing on the further side of the chamber *a*, and the other in a bearing upon the arm or lever *e e*, *fig.* 1045., which is supported by its fulcrum, at the end *e*, in one of the standards, *f f*, and at the other end by a pin fixed in the connecting rod, *g g*. At the upper end of this connecting rod there is a cross-piece, or head *h*, having turned pivots at each end, upon which are placed small rollers, *i i*, resting upon a horizontal cam *k k*, which is made to revolve. This cam *k k*, by means of its gearing, causes the roll *b* first of all to wash the rags a short time, then to be lowered at whatever rate is desired for breaking the fibres; to be maintained at the lowest point for the required number of revolutions for beating; and to be raised and retained, as required, for the final purpose of

clearing the pulp. The upper or working edge of this cam is to be shaped exactly according to the action required by the engine roll; as, for instance, suppose the previous operation of washing to be completed, and the time required for the operation of the rag machine to be three hours, one of which is required for lowering the roll, that, or the first division of the working surface of the cam, *k k*, must be so sloped or inclined, that, according to the speed at which it is driven, the rollers upon the cross-head shall be exactly that portion of the time descending the incline upon the cam, and consequently lowering the roll upon the plates *a*, *fig.* 1046; and if the second hour shall be required for the roll to beat up the rags, the roll revolving all the time in contact with the plates, the second division of the cam, *k k*, must be so shaped (that is made level), that the roll shall be allowed to remain, during that period, at its lowest point; and if the third portion of the time, or an hour, be required for raising the roll again, either gradually or interruptedly, then the third division of the cam, *k*, must be suitably shaped or inclined, so as to cause the cross-head to lift the roll during such interval or space of time; the particular shape of the inclined portions of the cam depending on the manner in which the manufacturer may wish the roll to approach to or recede from the bottom plates, during its descent and ascent respectively.

Its mode of connection and operation in the rag engine is as follows: supposing that the rags intended to be beaten up are placed in the vessel *a*, *fig.* 1046., and motion is communicated, from a steam-engine, or other power, to the farther end of the shaft *d*, the roll, *b*, will thus be caused to revolve, and the rags washed, broken, and beaten up, as they proceed from the front weir, *m*, over the bottom plates *n*, and again round by the back weir *o*. There is a small pulley *p*, upon the near end of the shaft *d*, round which a band *q* passes, and also round another pulley *r*, upon the cross shaft *s*; upon this shaft is a worm *t*, gearing into a worm-wheel *u*, fixed upon another shaft *v*, below; upon the reverse end of which is a pinion *w*, gearing into a spur-wheel *x*, upon the end of a shaft *y*; and upon the centre of this shaft *y*, there is another worm *z*, gearing into a horizontal worm-wheel *l*, upon which the cam *k k* is fixed. Thus it will be seen, that the requisite slow motion is communicated to the cam, which may be made to perform half a revolution in three hours; or it will be evident that half a revolution of the cam *k k*, may be performed in any other time, according to the calculation of the gearing employed. The shaft may also be driven by hand, so as to give the required motion to the cam. Supposing, now, at the beginning of the operation, the cross-head bearing the lever and roll, to be at the highest point upon the cam, *k k*, as its revolution commences, the roll will revolve for a short time on the level surface of the cam, and will then be lowered until the cam, *k k*, has arrived at that point which governs the time that the roll remains at the lowest point, for the purpose of beating the rags into pulp, and as the cam, *k k*, continues to revolve, and thus brings the opposite slope upon the third portion of its working surface into action upon the cross head, the roll will be raised, in order to clear the pulp from knots and other imperfections, and thus complete the operation of the engine. In order to raise the cross head and roll to the height from which it descended without loss of time, or to lift the cross head entirely from off the cam when requisite, a lever *2*, or other suitable contrivance may be attached to the apparatus, also a shaft may be passed across the rag-engine, and both ends of the roll may be raised instead of one only, as above described.

The patentee does not claim as his invention the lowering and raising the roll of the rag engine, nor the lowering of it by mechanism, as this was effected in Mr. Amos's patent of 1840; but he claims the above peculiar apparatus for this purpose.—*Newton's Journal*, xliiii. 254. C. S.

Quantity of Paper charged with Duties of Excise, in the United Kingdom, in

| | 1834. | 1835. | 1836. |
|-------------------------------|----------------|----------------|----------------|
| | <i>lbs.</i> | <i>lbs.</i> | <i>lbs.</i> |
| First Class - - - | 54,053,721 | 56,179,555 | 66,202,689 |
| Second Class - - - | 16,552,168 | 17,863,095 | 15,906,258 |
| Pasteboard, millboard, &c. - | 49,392 | 49,772 | 36,340 |
| | <i>yards.</i> | <i>yards.</i> | <i>yards.</i> |
| Stained - - - - | 8,749,144 | 8,247,931 | 8,032,577 |
| | <i>£ s. d.</i> | <i>£ s. d.</i> | <i>£ s. d.</i> |
| Amount of duty, first class - | 675,671 10 0 | 702,244 9 0 | 651,699 0 0 |
| — second class - | 103,451 0 0 | 111,644 0 0 | 99,414 0 0 |
| — pasteboard, &c. - | 54,689 0 0 | 54,548 15 0 | 39,557 0 0 |
| — stained - | 63,795 16 0 | 60,141 0 0 | 22,112 0 0 |

The late reduction of the duty, from 3*d.* to 1½*d.* per lb., upon paper of the first class, viz., on all descriptions of it, except that made out of tarred ropes only, has been already attended with considerable benefit to the manufacture, and would have acted with much greater effect, but for the American crisis. The gross amount of the paper duty in the year ending 5th January, 1836, was 831,057*l.*, and in the year ending 5th January, 1838, it was 554,497*l.*; instead of being little more than one half, as might have been the case from the reduction of the duty, which only came into full operation in the year 1837. The gross revenue in 1841 was, 633,520*l.*, the nett, 583,647*l.*, in 1844, 709,320*l.* gross, 609,906*l.* nett; in 1847, 810,944*l.* gross, 762,172*l.* nett; in 1850, 915,121*l.* gross, 852,966*l.* nett. Paper of all kinds charged with duty in 1850, 925,520*l.* At the same time that the tax on common paper was reduced, that upon stained paper was repealed altogether. The effect of the diminution consequently made in the price of paper-hangings, has been so great as nearly to double the consumption of the country, while the manufacture appears to be still rapidly on the increase.

Declared Value of Stationery and Printed Books exported in

| Years. | Stationery. | Printed Books. | Total. |
|--------|-------------|----------------|---------|
| | £ | £ | £ |
| 1827 | 195,110 | 107,199 | 302,309 |
| 1828 | 208,532 | 102,874 | 311,406 |
| 1829 | 190,652 | 109,878 | 300,530 |
| 1830 | 171,848 | 95,874 | 267,722 |
| 1831 | 179,216 | 101,110 | 280,326 |
| 1832 | 177,718 | 93,038 | 270,756 |
| 1833 | 211,518 | 124,535 | 336,053 |
| 1834 | 211,459 | 122,595 | 334,054 |
| 1835 | 259,105 | 148,318 | 407,423 |
| 1836 | 301,121 | 178,945 | 480,066 |

Till the paper trade shall escape entirely from the clutches of its ancient dry-nurse, the excise, neither it nor the book trade can acquire the same ascendancy in exportation which all other articles of British manufactures have over the French.

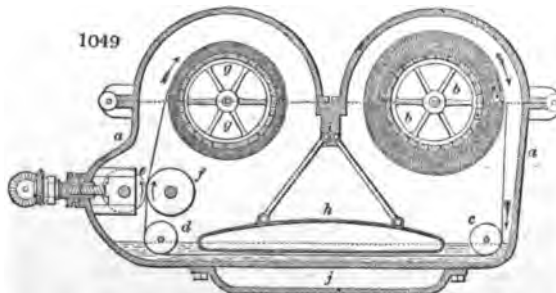
The Value of Stationery exported in France, from 1833, was,

| | |
|--|---------------|
| Cartons lustrés (polished pasteboards for the cloth manufacture) | 18,992 francs |
| Cartons en feuilles (pasteboard in sheets) | 6,352 — |
| Cartons moulés (papier-maché, | 215,376 — |
| Cartons coupés et assemblés | 54,184 — |
| Wrapping paper | 178,544 — |
| White paper, and rayé (ruled) pour musique | 2,903,075 — |
| Coloured paper in reams | 58,541 — |
| Stained paper (paper hangings) in rouleaux | 1,885,387 — |
| Silk paper | 3,240 — |

Total (= £208,000)

5,323,621 francs.

Mr. John Dickinson's invention for sizing paper, continuously, in an air-tight vessel, (partially exhausted of air,) by unwinding a scroll of dried paper from a reel, and con-



ducting it through heated size; then, after pressing out the superfluous size, winding the paper on to another reel.

A longitudinal section of the apparatus employed for this purpose, is represented in *fig* 1049. *a*, is the air-tight vessel; *b*, the reel upon which the paper to be sized is wound, from whence it proceeds beneath the guide-roller *c*, and through the heated size, to another guide-roller *d*; it then ascends between the press-rolls *e*, *f*, (by the revolution of which the paper is drawn from the reel *b*, (and is wound upon the reel *g*). A float *h*, is suspended from the cross-bar *i*, of the vessel *a*, for the purpose of diminishing the surface of size exposed to evaporation; and beneath the bottom of the vessel is an enclosed space *j*, into which steam or hot water is introduced, for raising the temperature of the size.

Water-marks. — In the manufacture of all hand-made papers, for the purpose of writing or printing upon, and of much machine-made paper, for the like purposes, it is the practice to form therein a device, name, and date, or some of them, known as the water-mark. These marks are produced by attaching to the surface of the mould or dandy roller, employed in the manufacture of paper (usually by sewing with fine wire), cylindrical and sometimes flattened wire, previously formed into the designs or marks intended to be produced in the paper; which designs or marks, thus attached to and lying above the general surface of the mould, occupy a space thereon, which if they had been absent, would have been charged with pulp, and thereby cause the sheet of paper in progress of manufacture to be thinner at the particular parts of the mould where the marks or designs are attached, by the thickness of the wire used in the same marks or designs; and the same apparent effect is indeed produced upon the sheet of paper in progress of manufacture as is produced by an ordinary die on any substance it may be caused to act upon, — with this difference, however, that on the sheet of paper the impression is the sunken one.

It is obvious, from the use of cylindrical wire, or flattened wire, having its sides parallel with each other, that the mark ultimately produced will be formed of a number of lines of equal breadth; unless, indeed, in the same figure, wires of different gauges, thicknesses, or breadths, be employed; and even in the latter case (which, indeed, in practice, it is believed seldom occurs), the transition from the different gauges would be abrupt and ill adapted to the proposed end. Also in forming designs of intricacy with wire, a frequent crossing of it is necessary; by which means, at the points of crossing, the mark will necessarily be the thickness of two wires, and, consequently, the water-mark on the sheet of paper will be stronger at those points; or, if to avoid the crossing the wire be cut, so that an end might abut against the length of the wire in an intricate design, the pieces of wire would be so short and so numerous as to render the sewing or fastening of them to the mould exceedingly difficult and of great expense, and, in some cases, wholly impracticable. With respect to the imitation of hand-writing, or the introduction of fac-simile autographs as water-marks, it is scarcely necessary to observe, that the observations before made, in relation to general designs, will apply with greater force to them; and that, at the best, they would be very imperfect, and in many cases, could not be effected at all. The remarks made, with reference to the water-marking upon moulds, is equally applicable to dandy rollers.

The object of this invention is to remedy the defects before pointed out, and to produce a simple mark, or one of the highest ornamental character or intricacy; the lines of which may vary from a thin line or faint shade to one of a greater depth of tone or breadth; or, on the contrary, from a depth of shade to a fainter one; and also to afford facility for introducing water-marks of the greatest intricacy, without the inconvenience or expense, before alluded to, of crossing the wire, and thus rendering some parts thicker than the main body of the mark, or cutting the wire into innumerable small pieces.

These effects are attained by the following means, whereby also the patentees is enabled to produce fac-similes of ordinary hand-writing and of autograph signatures: — A plate of brass, copper, or other metal, being provided, of the requisite substance to produce the depth of water-mark impression in the pulp (which substance must be determined according to the required weight or thickness of the paper) — to one side of this plate is to be attached, by glue or other suitable means, a piece of card-board or veneer of wood, for the purpose of giving it rigidity and support; and the design to be produced in the pulp as a water-mark, having been drawn on paper, is then to be affixed, by glue or other suitable means, to the other surface of the plate. If the sheets of paper to be manufactured are not required to be very heavy, the plate may be thin; and two thin plates of metal may be attached together, and be operated upon at one time. In this case, the paper, with the draught of the design, may be affixed to the outer surface of one of a pair of plates, previously attached together by glue, or other matter, having a piece of card-board or veneer of wood between them, for the purpose of keeping the two thicknesses of metal in contact, and for giving them rigidity. The

plate, supported as stated, or the pair of plates, connected as described, is or are then to be pierced or perforated round the outlines of the device by a saw, adapted to the purpose (after the method of cutting buhl work), according to the pattern or design drawn as before mentioned. The plate or plates having been so pierced, perforated, or cut to the figure of the device, those portions of the metal intended to form the device or water-mark are then to be disengaged from the parts of the plate or plates not required: which having been done, the drawn paper device, card-board, or veneer, must be removed; and if two plates of metal have been cut at one operation, they are to be separated from each other: this separation, as well as the removal of the drawn paper device, card-board, or veneer, can be effected by soaking in hot water or other suitable means. The designs or patterns, thus produced, are now to be attached to the surface of the mould or dandy-roller employed by the paper-maker: which may be done either by sewing with wire, as in the ordinary method of attaching water-marks to moulds or dandy-rollers, or by solder.

In cases where a high finish to the water-mark or design is required or desirable, the edges, and such other parts of the metal as may be desired, should be chamfered off, rounded, or cut down. In order to do this, the metal devices or parts of the plate or plates are to be affixed, by some sufficient means, to a rigid block, to hold them whilst operating upon: the method which the patentee has adopted, is to glue the cut metal device to a flat slab of marble, somewhat larger than the device; and this admits of its being readily removed by soaking in hot water, after the operation, next described, has been performed. The pattern or metal device being thus affixed, the upper surface thereof is then to be dressed by cutting or filing at the parts where it may be necessary, to improve the effect of the pattern; and the edges which have been left sharp by the saw can be removed or rounded by the scoper or engraver's tool, and then finished off by stoning or other suitable means. The above method of finishing the marks or designs applies only where the device is to be sewn on to the mould or dandy-roller with wire; but when solder is used, the metal device may—after having been cut, as before mentioned, and cleared from the other parts of the cut plate, card-board, or veneer—be at once affixed by solder to the mould or dandy-roller; and the dressing may be then effected by the scoper or engraver's tool, and the subsequent operation of stoning be performed, as before mentioned.

The patentee, Mr. R. O. Bancks, claims as his improvement or improvements in the manufacture of paper, the adaptation of marks or devices, pierced or cut from plates of metal, or other suitable substance, by saws or other instruments, as described, to the moulds or dandy-rollers used in the manufacture of paper, for the purpose of producing water-marks therein.

Messrs. Amos and Clare have obtained a patent for employing in place of the upper couch roll (for working against the upper surface of the paper), a hollow roll, perforated on its surface, having a section box within it, acted upon by an air pump, whereby the deposition of colouring matter is rendered equal on both sides of the paper, instead of being greater on the lower side, by the natural subsidence of the colouring matter from the water. They have also specified an improved knotter or pulp strainer, and various other improvements on the ordinary paper machines.—See *Newton's Journal*, xxxvii. 7.

PAPER PULP-METER. Patented by Charles Cowan, Valley-field, near Edinburgh. The object of this apparatus is to measure out a uniform and exact supply of pulp to the paper machine, according to any width and thickness of the web of paper which it may be desired to make. The pulp after having been prepared in the engines, and mixed in ascertained proportions of raw materials and water, is kept in the pulp or stuff chest. The cup of the pulp-meter which is driven in connection with the paper machine is made to dip into a box, which by means of a ball-cock or valve is always kept full of pulp from the pulp-chest and lifts, and delivers the requisite quantity of pulp to make the width and thickness of the web required. This is done by means of the slide upon the cup, which can be set even while the apparatus is in motion, so as to deliver the number of cubical inches of pulp at each dip required for the particular paper to be made, which can be ascertained by a very simple calculation. In this way uniformity of thickness in every sheet of the paper manufactured is readily obtained.

PAPER AND PRINTING. (*Exhibition.*) Paper of every description, printing and bookbinding, with the miscellaneous articles connected with correspondence, and useful and ornamental stationery, form the subject of the present class. The manufacture of these articles, ministering not to the personal or domestic wants of mankind, so much as to their intellectual requirements, is one the annual increase of which is coextensive with the diffusion of knowledge. And it may be truly said, that, morally and intellectually considered, the present class relates to a species of industry exercising indirectly a more extensive influence over social economy than any of those into which the exhibition has been subdivided. Books, it has been said, carry the productions of the human mind

over the whole world, and may be truly called the raw materials of every kind of science and art and of all social improvement. The sub-classes are as follows:— A. paper, in the raw state as it leaves the mill, such as brown paper, millboards, printing, writing, and drawing papers, &c.; B. articles of stationery, as envelopes, lace papers, fancy papers, ornamental and glazed papers, sealing wax, wafers, inks of all kinds, &c.; C. pasteboards, cards, &c.; D. paper and scaleboard boxes, cartonnerie, &c.; E. printing, not including printing as a fine art, and printing inks and varnishes; bookbinding in cloth, velvet, vellum, &c.; fancy books, portfolios, desks, &c.

The localities from whence the articles exhibited have been sent are much less restricted than in preceding classes. Many of the exhibitors appear in the capacity of producers of small articles for fancy purposes; and as these are obviously capable of being made at home, requiring taste and minute skill rather than mechanical power for their manufacture, the places from which they have been forwarded for exhibition have not the special interest attaching to great producing towns or cities, where thousands of mechanics and operatives are all occupied in one department of manufacture. From the metropolis, however, where a large demand for such articles exist, the great proportion of them are derived. London also represents most largely the enormous printing resources of this country. But of these, as specimens only of single works can appear, but a faint idea can be gained from the examples exhibited. In one of the greatest establishments of the metropolis, twenty machines are constantly occupied, each of which is capable of throwing off from 3,000 to 4,000 impressions per hour, and in addition a large number of printing machines for fine work are employed. These great printing establishments resemble very closely the large manufactories of other districts, only their organization differs with the peculiar nature of the manufacture, if the mechanical production of printed books may be so termed.

Paper, more legitimately reckoned among manufactures than printing, has a certain limitation to districts for particular kinds. Considerably more is made in England than in Scotland or Ireland. Kent is celebrated for its fine writing and drawing papers. From Lancashire, Berkshire, Hertford, and Derbyshire, papers of various kinds are supplied. The quantity of paper annually manufactured in England two years ago amounted to 132,132,657 lbs.; in 1834, it was a little more than half that quantity. In 1839 it was estimated that the quantity used, if equally divided among the population, would have been about three pounds and three quarters for each individual.

A variety of mechanical improvements, both in the production of paper and in that of printed books, has been introduced of late. In the manufacture of paper, the substitution of machine for hand labour, has been attended with the most momentous results. In 1801, the price of a ream of paper of a particular description was 36s.; in 1843 the same paper could be purchased for rather less than half this sum. In 1721 it is estimated that 300,000 reams of paper were annually produced in Great Britain. In 1841 97,105,550 lbs., were made in the United Kingdom: the total annual value is at present not far short of two millions sterling. Much of the increase thus exhibited is due to the introduction of mechanical power; but the fiscal regulations upon this branch of industry, which were formerly extremely oppressive, having been removed to some extent, another cause of increased production and consumption is thus superadded. Paper may, however, be likewise regarded as a chemical product, as it is certain that a large amount of chemical knowledge has been successfully combined with mechanical skill in its preparation.

By the co-operative forces of chemical processes and mechanical instruments, the most refuse matter becomes converted into a white and pure material. As an evidence of the enormous length of paper produced by mechanical power two great rolls are exhibited; one is 750 yards long, the other 2,500 yards in length.

The application of improved machinery to printing is also of recent date, and has been attended with results of great moment. Progress is still made in this direction: an entirely new principle in printing (the vertical) has been introduced, the application of which for the rapid multiplication of newspapers is extending. By this arrangement (the vertical), the power of production is only limited by the size of the machine.

Among many interesting specimens of typography, those which exhibit the production of books in other tongues, by type cast in England, will attract notice. The Holy Scriptures are exhibited in one hundred and fifty different languages,—a noble evidence of the highest application of industry to the enlightenment and welfare of mankind. Beautiful specimens of the bookbinder's art are likewise shown.

An envelope-folding machine, placed at the side of the Main Avenue, is a striking instance of the successful application of mechanical movements to the performance of the most delicate and complicated actions. By this machine, the movements of the hand of the folder are not only exactly imitated, but the result is more accurate and certain, and the power of production is very largely increased.

The peculiar interest which attaches to the objects in this class, as the most powerful agents in the social and intellectual improvement of man, cannot fail to be awakened by the most casual inspection. Papers, printing, and bookbinding, are, however, only the raw material, the application and reproduction of which is dependent upon the powers of the mind, not on those of matter.

10. *Fisher, Jabez Henry, New North Road, Hoxton, Inventor.*—Specimen of a bank-note for the prevention of forgery, printed in a chemical watercolour, from a steel-plate engraving, the process producing two colours at one operation; the lettering in black, and the ornamental background in a neutral tint. Any signature upon this note cannot be erased without changing the colour. The letterpress on the note cannot be transferred or copied, and is printed on a prepared paper.

23. *Kirby, John, 103 Cornwall Road, Lambeth, Producer.*—Specimens of split paper and improved method of mounting woodcuts, for illustrating books, framing, and other purposes, and for their better preservation.

The method of splitting paper of the thinnest texture is extremely simple. Two pieces of calico are firmly cemented on the sides of the paper and dried. By a gentle pull on each side, the paper splits into halves, one of which adheres to the calico on one side, and the other to its opposite, the adhesion between the paper and the calico being greater than that of the surfaces of the paper to each other. The split portions may then be removed by damping, and so loosening the paste between the calico and paper. A bank-note, although of extremely thin texture, can in this way be separated into two halves, on one of which remains the impression of the plate, while the other is blank.

In the interesting collection of paper in the Exhibition from various paper mills, there are groups whose degrees of excellence must be estimated by very different standards; as, for instance, the brown wrapping and the fine hand-made drawing papers, the sugar and the fine printing papers, the bibulous plate-paper for engravers' use and the hard sized writing papers. Collectively, it exhibits at one view the various qualities which are sought for by English consumers, and which in many respects differ from those required by our Continental neighbours; as an example, may be quoted the substantial English writing-papers and the thin post papers of France and Belgium, whose different qualities arise from the difference of postal regulations in those countries.

The system of producing paper in continuous lengths by machinery was first introduced by Messrs. Fourdrinier into this country, they having purchased the patent right of Mr. Gamble, who in 1804, obtained permission from the French government to bring to England a model of a machine invented in 1799 by Louis Robert, who was then employed in the paper works of Essonne. This machine of Mr. Robert was essentially imperfect, but it was brought to a state of perfection for Messrs. Fourdrinier by the ingenuity of Mr. Bryan Donkin: upon this has been founded the various descriptions of paper-making machines which have since that time been introduced. They consist essentially of contrivances by which the paper pulp is made to flow on the surface of an endless wire web; a rapid up and down motion being given to it for the purpose of baking the water out of the pulp, and thus producing a complete interweaving of the textile filaments. The continuous roll of paper thus formed is turned off upon a second solid cylinder covered with felt, upon which it is condensed by a third, and eventually delivered to drying rollers.—*Exhibition, Report of.*

Swedish filtering paper is made with pure water, and is more free from impurity than any other; this is, in fact, pure cellulose, and yields only half a per cent. of ash on incineration.

Laid papers are those with a ribbed surface; wove papers those with a uniform surface. Blue papers under the microscope no longer appear of uniform tint; on the contrary, the particles of colour are seen widely separated.

In reference to the pulp in its various stages of preparation, it may be stated that numerous attempts have been made to employ other fibres besides those of cotton and flax, in the manufacture of paper; for instance, straw, hop-bine, grasses, refuse of sugar cane, wood shavings, &c.; and, although paper has been produced from these materials, yet, commercially, the attempts have been unsuccessful.

76. *De la Rue, Thomas, & Co., 110 Bunhill Row, Manufacturers and Proprietors. Envelope-folding machine invented by Edwin Hill and Warren De la Rue.*—The following is the action of this machine:—The feeding-boy places the previously cut blank envelopes on to a small platform, which rises and falls in the rectangular recess formed by the cylindrical axes of the folders, the bearings of the folders serving by their elongation to guide the envelope into its place at the moment of the small platform falling. A plunger now descends and creases the envelope by carrying it between the folder-axes, at the same time turning the flaps upwards in a vertical direction. The plunger, which descends as a whole, now divides into two parts, the ends rising and the sides

remaining down to hold the envelope until the end-folders have operated; these latter turn over the flaps, the one on the right of the feeding-lad taking a slight precedence, and being closely followed by the gumming apparatus, which takes gum from an endless blanket working in a trough, and, after applying it to the two end flaps, retires, at the same time the remaining half of the plunger moves upwards, to allow of the side folders turning over the remaining two flaps, the folder nearest the feeder taking precedence. During these operations, the end folders have remained at rest, and the whole four open simultaneously. The taking-off apparatus with its fingers tipped with vulcanized caoutchouc, now moves forward over the folded envelope, which is lifted upwards by the rise of the small platform and retreats with it, placing each envelope, as it is successively folded, under those which have preceded it. The envelopes are now knocked over on to an endless blanket, and are conducted by it between two cylinders for a final squeeze, and then rise in a pile up the trough. There is a provision in the machine by which the gummer is prevented placing gum upon the platform, in case the feeder omits feeding in an envelope. This machine works at the rate of 2,700 envelopes per hour, and although superseding hand-labour in folding, it is satisfactory to find that, instead of displacing hands, its introduction, by extending the consumption, has in reality created work for more than it has displaced.

Although the fashion of using envelopes was common in France, and had been, to a small extent, introduced into England prior to 1839, yet their consumption was too insignificant to call forth any but the rudest mechanical appliances. It is to the stimulus created by the adoption, in 1839, of Mr. Rowland Hill's system of postage reform, and the consequent increased demand for envelopes, that their manufacture owes its rank amongst the arts, and its possession of some of the most ingenious machinery recently invented.

The total annual number of letters passing through the Post-Office in the United Kingdom before the change in the postage was about 76,000,000. The fourpenny rate and the alteration in the system of charge by number of enclosures to that by weight, was introduced on the 5th of December, 1839, and on the 10th of January, 1840, the rate was reduced to one penny; during that year the number of letters increased to 169,000,000, about half of which were enclosed in envelopes. The number of letters has been steadily increasing since that period, and during the year 1850, it reached the astonishing number of 347,000,000, or 1,000,000 per day; the proportion of letters enclosed in envelopes has likewise increased from one-half to five-sixths of the total quantity, so that in round numbers 300,000,000 of envelopes pass annually through the Post-Office; besides which there is nearly an equal number used in private conveyance. What does this million of envelopes contain? Their exposition would furnish an instructive and entertaining study.

In illustration of the articles sometimes sent by post, it may be cited, that some years back, Professor Henslow was in the habit of receiving from members of an agricultural society which he had established, specimens of living slugs of various kinds, sent for examination, with a view to his advice for their extermination. Were it not for the cheap postage, many of the publishing societies now in existence would not have been established, on account of the expense of collecting manuscripts, transmitting proofs, and circulating books. But it is not only in this way that the postal reform has extended its benefits, for with the reduction of rates, a liberal policy has increased the facilities of delivery by the establishment since 1839 of 4,600 new post offices, which are estimated as serving about 14,000 villages.

154. *Specimens of Books and Tracts of the Religious Tract Society*, instituted 1799. Depositories, 56. Paternoster Row, 65. St. Paul's Churchyard, and 164. Piccadilly. Treasurer, John Gurney Hoare, Esq.; Honorary Secretaries, Rev. W. W. Champneys, M.A., and Rev. Ebenezer Henderson, D.D.; Corresponding Secretary, Mr. Jones.

The Society was formed to promote the circulation of religious books and treatises in foreign countries, as well as throughout the British dominions. It constitutes a Christian union of members of the Established Church and of Protestant dissenters. It has printed important tracts and books in about 100 languages; its annual circulation from the depository in London, and from various foreign auxiliaries, amounts to about 24,000,000; its receipts for sales and benevolent objects, to more than 62,000*l.*; and its total distribution to March, 1851, including the issues of its affiliated societies, to about 549,000,000 copies of its publications. There are now about 4,743 English publications, besides several hundred in foreign languages, on its catalogue. These works are varied in size and contents, and suited to different classes of the community. Several books and tracts specially designed to improve and commemorate the Great Exhibition have been issued in English, French, German and Italian. By a carefully arranged system in the concerns of the depository, the sale of the publications is made to cover all the expenses of producing them, and of the necessary establishment of the Society.

Thus, the whole of the subscriptions, donations, and contributions is applied to the gratuitous circulation of its publications, without any deduction or charge whatever. In aid of home and foreign benevolent objects the Society receives about 6,560*l.*, per annum, while its grants during the past year were 8,560*l.*, being 2,000*l.* beyond the receipts. The committee have supplied 3,028 libraries at half price to national, British, parochial, day, and Sunday schools, which were unable to pay the full amount.

The total grants of libraries for various interesting objects amount to 6,055.

The Society has translated, printed, and circulated works in the following languages:—

Northern Europe.—Icelandic, Swedish, Lapponese, Finnish, Danish, Norwegian.

Southern Europe.—French, German, Latin, Romanese, English, Italian, Maltese, Modern Greek, Albanian, Turkish, Turkish in Greek character, Turkish in Armenian character, Moldavian, Bulgarian, Syriac.

China and Indo-Chinese Countries.—Chinese, Assamese, Shyam, Nagas, Burmese, Peguan, Talung, Karen, Siamese, Laos, Cambodian, Cochinchinese, Loo-Chooan, Japanese, Corean, &c.

Through the disinterested agency of devoted friends and missionaries of different denominations, several languages have, for the first time, been brought into a written form, and a sacred character has been given by the Christian press to the earliest literature of a people just emerging from a state of barbarism. As an illustration of the extent of the Society's operations, it may be stated that Bunyan's celebrated work, "The Pilgrim's Progress," has been issued in 28 of the principal languages of the earth, spoken probably by more than one-half of the human family. In some instances the work has been printed in Roman characters, as in the following example:—

In Tahitian, for the inhabitants of various islands in the Pacific Ocean, thus:—

I to'u bahaere raa na roto i medebara o teie nei ao, haeri atura van i te hoe vahi, e ana tei taua vahi ra, tapae atura vau i reira e roohia ihora i te taoto i roto i taua ana ra.

The original of this translation is the following:—

As I walked through the wilderness of this world, I lighted on a certain place where was a den, and laid me down in that place to sleep, and as I slept I dreamed a dream.

171. *Gall, James, Myrtle Bank, Edinburgh, Inventor*.—Gall's triangular alphabet for the blind, which by its similarity to the common Roman alphabet is easily read by the eye, and may be taught without previous instruction. This alphabet is considered as an improvement on circular alphabets, by its angular form; the letters are rendered more distinct to the touch; and by the exclusion of the capitals, the attention of the blind is concentrated upon 26 instead of 52 letters, and the size of the printing may be reduced. Volume, containing the Epistle to the Ephesians, printed for the blind in Gall's triangular alphabet with letters serrated.

Gall's apparatus for writing by and to the blind.—The blind can by this invention readily correspond by post, and can keep books and other memoranda. The apparatus consists of a stuffed frame on which the paper is placed; of a cover with bars to guide the lines, which are written from the bottom upwards; and of small stamps, with the letters formed of common pins, which are pricked through the paper, and read on the opposite side. By means of the two register points on each side of the frame, and by shifting the cover one half line up, the paper is written on both sides, each perfectly legible either by the fingers or the eye.

174. *Muir, Robert, 4, Dunlop Street, Glasgow, Inventor*. Electro-stereotype plate for letter-press printing. This specimen is from a mould of gutta percha, taken from a page of diamond types in a screw press. The gutta percha was laid on warm, the pressure applied immediately, and left on for fifteen minutes. When the mould was taken off, it was brushed over with plumbago, and copper deposited upon it by the known process. When the copper deposit is backed up with gutta percha, it is ready for press.

The advantage of electro-stereotype over stereotype is that it will last much longer, and work much cleaner. The exhibitor has worked one of each together, and when the stereotype was completely worn, the electro-stereotype was as good as at first.

Gutta percha plate to be used in letter-press printing. Plates made of gutta percha from woodcuts, will work a large impression with letter-press; advantageous when woodcuts are expensive, as the originals might be saved. Gutta percha plates can be made in a short time at a trifling cost; and when 2, 4, or 6, are worked together, it will greatly facilitate the work, and lessen expense.

Make a mould from a woodcut by the method above described; brush it over with plumbago; lay it on the press, face up, and put warm gutta percha into it; apply the pressure as before. Several plates may be got from the same mould.

This process appears to offer many advantages, if the practical difficulties of completely

covering the impressions of the type letters, or the lines of an engraving, with plumbago are not too great. The gutta percha plate, being properly prepared, is connected with the voltaic battery, and placed in a solution of the sulphate of copper, which, when undergoing electro-chemical decomposition, deposits pure copper in all the lines and over the entire surface. It would appear, if lead was used instead of gutta percha for backing the plate, that it would be better fitted for printing than when gutta percha is employed.

175. *Wyld, James, Charing Cross, East, 454, West Strand, 2, Royal Exchange, and the Great Globe, Leicester Square,—Producer.* An Atlas of the World, comprehending 52 separate maps of its various countries, constructed and drawn from the latest astronomical and geographical observations. Imperial quarto, coloured and handsomely half-bound.

Popular Atlas, containing 48 maps of the various parts of the globe, with letter-press description to accompany each map.

The World on Mercator's projection. A new map containing the most recent geographical information, and constructed on a new principle; 4 large sheets. The World on Mercator's projection, coloured; one large sheet.

Post Roads of Germany and the adjacent states, with the posts marked. The railroads, the sea-packet routes, and the internal steam navigation. Two sheets in cases.

The British Isles, with the topographical and physical features; the lines of railway, their primary and intermediate stations; the land and water communications of the counties; and the steam packet routes, with the distance from port to port. Compiled from the Ordnance Survey; 2 sheets.

England, Wales, and the greater part of Scotland, a railway and topographical map, drawn from the triangulation of the Ordnance Survey, and the surveys of the railway companies and other sources of information, showing the lines of railways, the inland navigation, the great and cross roads, cities, market towns, and villages, with the physical features. 4 sheets.

Plans of London and Westminster, with the Borough of Southwark, including the adjacent suburbs, with all the additions and improvements to the present time, reduced from the large survey, with an alphabetical list of the principal streets, squares, public buildings, &c., and reference to their situation on the plan; also a statistical table of the population, &c. 2 sheets.

Map of the country 25 miles round London, upon a scale of 1 inch to the mile, showing the turnpike and cross roads, railroads, and stations, rivers, woods, commons, seats of the nobility and gentry, as well as the market towns, villages, &c. 4 sheets.

201. *British and Foreign Bible Society, Earl Street, Blackfriar,—Producer.* Specimens consisting of 165 books in different languages, from the 170 versions of the Holy Scriptures, either in whole or in part, which have been published, directly or indirectly, by the Society, and of which 118 are from translations never before printed; and of which more than twenty-four millions of copies have been circulated since its institution in 1804.

Eight specimens of four editions of the English Bible, showing the improvement made between the years 1816 and 1851, in reference to quality of paper, printing and binding, at an average reduction of 62 per cent. in the cost price.

PARAFFINE. Distil beech-tar to dryness, rectify the heavy oil which collects at the bottom of the receiver, and when a thick matter begins to rise, set aside what is distilled, and urge the heat moderately as long as any thing more distils. Pyréline passes over, containing crystalline scales of paraffine. This mixture being digested with its own volume of alcohol of 0·833, forms a limpid solution, which is to be gradually diluted with more alcohol, till its bulk becomes 6 or 8 times greater. The alcohol, which at first dissolves the whole, lets the paraffine gradually fall. The precipitate being washed with cold alcohol till it becomes nearly colourless, and then dissolved in boiling alcohol, is deposited on cooling in minute spangles and needles of pure paraffine.

Or the above mixture may be mixed with from $\frac{1}{4}$ to $\frac{1}{2}$ its weight of concentrated sulphuric acid, and subjected for 12 hours to digestion, at a heat of 150° F., till, on cooling, crystals of paraffine appear upon the surface. These are to be washed with water, dissolved in hot alcohol, and crystallized. Paraffine is a white substance, void of taste and smell, feels soft between the fingers, has a specific gravity of 0·87, melts at 112° Fahr., boils at a higher temperature with the exhalation of white fumes, is not decomposed by dry distillation, burns with a clear white flame, without smoke or residuum, does not stain paper, and consists of 85·22 carbon, and 14·78 hydrogen; having the same composition as olefant gas. It is decomposed neither by chlorine, strong acids, alkalis, nor potassium; and unites by fusion with sulphur, phosphorus, wax, and rosin. It dissolves readily in warm fat oils, in cold essential oils, in ether, but sparingly in boiling absolute alcohol. Paraffine is a singular solid bicarburet of hydrogen; it has not hitherto been applied to any use, but it would form admirable candles.

The interesting researches of Reichenback, above briefly detailed, have lately begun to assume a more practical aspect in consequence of the efforts made by several companies in this country to work up or utilise the peat bogs of Ireland. The progress yet made in this patriotic endeavour has not been such as to hold out any great hope, either that the project will pay in a commercial sense, or that the peat of Ireland can be utilised at anything short of a great national sacrifice. In fact, all the money hitherto invested in these peat projects has been as completely lost to its owners as if it had not only really, but literally, been thrown into a bog. Part of this unsatisfactory result is no doubt owing to the newness of the undertaking, to the want of practical knowledge, and to the purely visionary and unfounded calculations of the projectors, who have rushed at conclusions in unison rather with their wild hopes than with the sober deductions of scientific experience, and without any solid data upon which to found their egregious assertions have made "the wish father to the thought," and declared that to be a fact which had scarcely the consistence of a vague probability. As the subject is one essentially contained within the realms of manufacturing chemistry, we deem it requisite to give a general view of these peat schemes, but without entering into a specific examination of any one project. By one class of schemes, the solid or fixed residue of the peat is chiefly contemplated, by another the fluid and gaseous or volatile products are sought for, whilst a third class unites both fixed and volatile products, and may therefore be said to comprehend the whole question. The first includes the makers of peat charcoal *per se*; the two last come more immediately within the scope of our observations, and although these have hitherto failed to elucidate the principles upon which the manufacture of peat into saleable products depends, they have nevertheless brought forth an abundance of evidence, that more is to be done in this way than was previously anticipated by scientific men. When peat is subjected to distillation at a red heat it evolves matters precisely similar to those given off by wood and some kinds of bitumen, that is to say, tar, acetic acid, pyroligneous spirit, ammonia, and gas: these substances, though constant in their presence, are, however, extremely variable in their quantities, owing to the degree of heat which has been employed for their production. Thus, if a very high temperature be employed, little else than gas is produced, whereas with a very low and dull red heat the quantity of tar is prodigiously increased. The latter is therefore the temperature most to be desired, but as this low heat necessitates a very slow and long continued process, the common practice is to steer a middle course, between loss from destruction of products on the one hand, and cost from slowness of production on the other. In the case of wood distillation, where the profit is chiefly looked for from acetic acid, this middle course is unquestionably correct, and guiding themselves by this description of experience the distillers of peat have resorted to the same method. Indeed, they have even sought by an increased temperature to quicken their operations, and compensate by this means for the comparative poverty of the article they had to employ, since peat is not nearly so rich in valuable products as wood is. But this had given rise to a great and fatal error, which nothing but a want of perception as regards the differences of the two cases could for one moment have permitted. With wood it is, as we have said, acetic acid which forms the chief item of value; with peat the acetic acid is not worth collecting; with wood the paraffine is a mere bagatelle, whereas with peat the paraffine must be regarded as the mainstay of the manufacture, and without which the peat of Ireland will remain as it is, until that seemingly remote period of future history, when the arts and manufactures shall have reached in that country a degree of perfection akin to what now prevails throughout Great Britain. To make charcoal, or to make any bulky article of merchandise in Ireland, is mere folly at present, for as it cannot be used on the spot and must come to England for consumption, the cost of transit shuts it out of every market. Therefore a compact valuable substance like paraffine is precisely the kind of goods into which Irish peat may be turned with a fair prospect of remuneration, for were it not for the expense of carriage, the peat itself might be sent to market. In the manufacture of peat-products every effort ought therefore to have been directed to the increase of this article. All else might and ought to have been held subsidiary to this one point, and more especially so as the very means which serve to insure a large formation of paraffine have the same effect upon the production of the pyroligneous spirit, which is the only other article that peat yields of a quality to pay the cost of transit.

But no well directed efforts have hitherto been applied in this direction, and the utmost amount of paraffine and pyroligneous spirit obtained by any one of the peat companies now struggling for existence in Ireland has been only at the rate of three pounds weight of paraffine and half a gallon by measure of pyroligneous spirit from one ton of peat. True, indeed, several gallons of very fetid and worthless oil have also resulted, but these add nothing to the profit of the undertaking. As it is very clear that the working of peat at present can never pay unless some very important modifications are introduced into the existing processes,

we shall here briefly describe the conditions upon which alone success can be hoped for, and leave it to those interested in the practical application of our remarks, to carry the principles out in detail. If either paraffine or pyroligneous spirit be passed in a state of vapour through a red-hot iron or porcelain tube, it will be seen that both of these substances are decomposed and destroyed: from the former a quantity of gas, fœtid oil, and charcoal results, from the latter, gas and a minute quantity of volatile oil alone arise. In both cases, however, the material operated upon is destroyed by the heat, and resolved into worthless products, and this is the only observation which need be made in connection with such an experiment, for it demonstrates most conclusively that in the distillation of peat as now practised, nearly the whole of the paraffine and pyroligneous spirit must be destroyed, except the small quantity mechanically protected from the heat, and carried forward to the condenser by the gaseous products simultaneously evolved with it. It is, we say, obvious that the 3 lbs. of paraffine now procured from 1 ton of peat, must have been mechanically carried out of the red-hot furnace or retort too rapidly for the destroying agency of the heat to have acted upon it, and but for this action of the gas, no paraffine whatever would be obtained, and the same remark applies to the pyroligneous spirit. Such being the case, it appears to us that as the gas given off by peat is not, under any circumstances, very large, this ought to be reconducted over fresh peat in the act of distillation, by which the nascent paraffine and pyroligneous spirit will be rapidly swept out of the retort, and carried away from the injurious effect of the heat into the condenser, whence they may be securely taken. It cannot be necessary that we should enter into a detail of the arrangements requisite for completing the idea here developed; the principle is substantially explained above, and nothing can be simpler than to devise the mechanical construction of retorts adapted for such a purpose. Either a system of reciprocation between one retort and another, or between two separate beds of retorts, or the collection and subsequent use of the gas into and from a holder, might be put in practice. The main feature would still continue, and depend upon the same circumstance, viz., the restricted agency of the heat upon the recently volatilized products of the peat.

In this way there can be no doubt that much of the paraffine now resolved into worthless gas may be turned into the market in a solid form, and if even the increased production of this article extended no farther than from 3 lbs. to 10 lbs. from every ton of peat, yet this alone would be sufficient to resuscitate the hopes of commercial men, and convert the bogs of Ireland into firm and substantial materials for the investment of British capital and enterprise,—“a consummation most devoutly to be wished.”—*Mr. Lewis Thompson.*

PARCHMENT. (*Parchemin, Fr.; Pergament, Germ.*) This writing material has been known since the earliest times, but is now made in a very superior manner to what it was anciently, as we may judge by inspection of the old vellum and parchment manuscripts. The art of making parchment consists in certain manipulations necessary to prepare the skins of animals of such thinness, flexibility, and firmness, as may be required for the different uses to which this substance is applied. Though the skins of all animals might be converted into writing materials, only those of the sheep or the she-goat are used for parchment; those of calves, kids, and dead-born lambs for vellum; those of the he-goat, she-goat, and wolves for drum-heads; and those of the ass for battledores. All these skins are prepared in the same way, with slight variations, which need no particular detail.

They are first of all prepared by the leather-dresser. After they are taken out of the lime-pit, shaved, and well washed, they must be set to dry in such a way as to prevent their puckering, and to render them easily worked. The small manufacturers make use of hoops for this purpose, but the greater employ a *herse*, or stout wooden frame. This is formed of two uprights and two cross-bars solidly joined together by tenons and mortises, so as to form a strong piece of carpentry, which is to be fixed up against a wall. These four bars are perforated all over with a series of holes, of such dimensions as to receive slightly tapered box-wood pins, truly turned, or even iron bolts. Each of these pins is transpierced with a hole like the pin of a violin, by means of which the strings employed in stretching the skin may be tightened. Above the *herse*, a shelf is placed, for receiving the tools which the workman needs to have always at hand. In order to stretch the skin upon the frame, larger or smaller skewers are employed, according as a greater or smaller piece of it is to be laid hold of. Six holes are made in a straight line to receive the larger, and four to receive the smaller skewers or pins. These small slits are made with a tool like a carpenter's chisel, and of the exact size to admit the skewer. The string round the skewer is affixed to one of the bolts in the frame, which are turned round by means of a key, like that by which pianos and harps are tuned. The skewer is threaded through the skin in a state of tension.

Every thing being thus prepared, and the skin being well softened, the workman

stretches it powerfully by means of the skewers; he attaches the cords to the skewers, and fixes their ends to the iron pegs or pins. He then stretches the skin, first with his hand applied to the pins, and afterwards with the key. Great care must be taken that no wrinkles are formed. The skin is usually stretched more in length than in breadth, from the custom of the trade; though extension in breadth would be preferable, in order to reduce the thickness of the part opposite the backbone.

The workman now takes the fleshing tool represented under *CURATING*. It is a semi-circular double-edged knife, made fast into a double wooden handle. Other forms of the fleshing-knife edge are also used. They are sharpened by a steel. The workman seizes the tool in his two hands, so as to place the edge perpendicularly to the skin, and pressing it carefully from above downwards, removes the fleshy excrescences, and lays them aside for making glue. He now turns round the *herse* upon the wall, in order to get access to the outside of the skin, and to scrape it with the tool inverted, so as to run no risk of cutting the epidermis. He thus removes any adhering filth, and squeezes out some water. The skin must next be ground. For this purpose it is sprinkled upon the fleshy side with sifted chalk or slaked lime, and then rubbed in all directions with a piece of pumice-stone, 4 or 5 inches in area, previously flattened upon a sandstone. The lime gets soon moist from the water contained in the skin. The pumice-stone is then rubbed over the other side of the skin, but without chalk or lime. This operation is necessary only for the best parchment or vellum. The skin is now allowed to dry upon the frame; being carefully protected from sunshine, and from frost. In the arid weather of summer a moist cloth needs to be applied to it from time to time, to prevent its drying too suddenly; immediately after which the skewers require to be tightened.

When it is perfectly dry, the white colour is to be removed by rubbing it with the woolly side of a lambskin. But great care must be taken not to fray the surface; a circumstance of which some manufacturers are so much afraid, as not to use either chalk or lime in the polishing. Should any grease be detected upon it, it must be removed by steeping it in a lime-pit for ten days, then stretching it anew upon the *herse*, after which it is transferred to the *scraper*.

This workman employs here an edge tool of the same shape as the fleshing-knife, but larger and sharper. He mounts the skin upon a frame like the *herse* above described; but he extends it merely with cords, without skewers or pins, and supports it generally upon a piece of raw calfskin, strongly stretched. The tail of the skin being placed towards the bottom of the frame, the workman first pares off, with a sharp knife, any considerable roughnesses, and then scrapes the outside surface obliquely downwards with the proper tools, till it becomes perfectly smooth: the fleshy side needs no such operation; and indeed were both sides scraped, the skin would be apt to become too thin, the only object of the scraper being to equalize its thickness. Whatever irregularities remain, may be removed with a piece of the finest pumice-stone, well flattened beforehand upon a fine sandstone. This process is performed by laying the rough parchment upon an oblong plank of wood, in the form of a stool; the plank being covered with a piece of soft parchment stuffed with wool, to form an elastic cushion for the grinding operation. It is merely the outside surface that requires to be pumiced. The celebrated Strasburgh vellum is prepared with remarkably fine pumice-stones.

If any small holes happen to be made in the parchment, they must be neatly patched, by cutting their edges thin, and pasting on small pieces with gum water.

The skins for drum-heads, sieves, and battledores are prepared in the same way. For drums, the skins of asses, calves, or wolves are employed; the last being preferred. Ass skins are used for battledores. For sieves, the skins of calves, she-goats, and, best of all, he-goats, are employed. Church books are covered with the dressed skins of pigs.

Parchment is coloured only green. The following is the process. In 500 parts of rain water, boil 8 of cream of tartar, and 30 of crystallized verdigris; when this solution is cold, pour into it 4 parts of nitric acid. Moisten the parchment with a brush, and then apply the above liquid evenly over its surface. Lastly, the necessary lustre may be given with white of eggs, or mucilage of gum arabic.

PARTING (*Départ*, Fr.; *Scheidung*, Germ.), is the process by which gold is separated from silver. See *ASSAY*, *GOLD*, *REFINING*, and *SILVER*.

PASTEL, is the French name of coloured crayons.

PASTEL, is a dye-stuff, allied to *INDIGO*, which see.

PASTES, or FACTITIOUS GEMS. (*Pierres précieuses artificielles*, Fr.; *Glaspasten*, Germ.) The general vitreous body called *Strass*, (from the name of its German inventor), preferred by Fontanier in his treatise on this subject, and which he styles the Mayence base, is prepared in the following manner:—8 ounces of pure rock-crystal or flint in powder, mixed with 24 ounces of salt of tartar, are to be baked and left to cool. The mixture is to be afterwards poured into a basin of hot water, and treated with dilute nitric acid till it ceases to effervesce; and then the frit is to be washed till the water comes

off tasteless. This is to be dried, and mixed with 12 ounces of fine white-lead, and the mixture is to be levigated and elutriated with a little distilled water. An ounce of calcined borax being added to about 12 ounces of the preceding mixture in a dry state, the whole is to be rubbed together in a porcelain mortar, melted in a clean crucible, and poured out into cold water. This vitreous matter must be dried, and melted a second and a third time, always in a new crucible, and after each melting poured into cold water, as at first, taking care to separate the lead that may be revived. To the third frit, ground to powder, 5 drachms of nitre are to be added; and the mixture being melted for the last time, a mass of crystal will be found in the crucible, of a beautiful lustre. The diamond may be well imitated by this Mayence base. Another very fine white crystal may be obtained, according to M. Fontanier, from 8 ounces of white-lead, 2 ounces of powdered borax, $\frac{1}{2}$ grain of manganese, and 3 ounces of rock crystal, treated as above.

The colours of artificial gems are obtained from metallic oxides. The *oriental topaz* is prepared by adding oxide of antimony to the base; the amethyst, by manganese with a little of the purple of Cassius; the beryl, by antimony and a very little cobalt; yellow artificial diamond and opal, by horn-silver (chloride of silver); blue-stone or sapphire, by cobalt. The following proportions have been given:—

For the *yellow diamond*. To 1 ounce of strass add 24 grains of chloride of silver, or 10 grains of glass of antimony.

For the *sapphire*. To 24 ounces of strass, add 2 drachms and 26 grains of the oxide of cobalt.

For the *oriental ruby*. To 16 ounces of strass, add a mixture of 2 drachms, and 48 grains of the precipitate of Cassius, the same quantity of peroxide of iron prepared by nitric acid, the same quantity of golden sulphuret of antimony and of manganese calcined with nitre, and 2 ounces of rock crystal. Manganese alone, combined with the base in proper quantity, is said to give a ruby colour.

For the *emerald*. To 15 ounces of strass, add 1 drachm of mountain blue (carbonate of copper), and 6 grains of glass of antimony; or, to 1 ounce of base, add 20 grains of glass of antimony, and 3 grains of oxide of cobalt.

For the *common opal*. To 1 ounce of strass, add 10 grains of horn-silver, 2 grains of calcined magnetic ore, and 26 grains of an absorbent earth (probably chalk-marl). — *Fontanier*.

M. Douault-Wiéland, in an experimental memoir on the preparation of artificial coloured stones, has offered the following instructions, as being more exact than what were published before.

The base of all artificial stones is a colourless glass, which he calls *fondant*, or flux: and he unites it to metallic oxides, in order to produce the imitations. If it be worked alone on the lapidary's wheel, it counterfeits brilliants and rose diamonds remarkably well.

This base or strass is composed of silex, potash, borax, oxide of lead, and sometimes arsenic. The siliceous matter should be perfectly pure; and if obtained from sand, it ought to be calcined, and washed, first with dilute muriatic acid, and then with water. The crystal or flint should be made red-hot, quenched in water, and ground, as in the potteries. The potash should be purified from the best pearlsh; and the borax should be refined by one or two crystallizations. The oxide of lead should be absolutely free from tin, for the least portion of the latter metal causes milkiness. Good red-lead is preferable to litharge. The arsenic should also be pure. Hessian crucibles are preferable to those of porcelain, for they are not so apt to crack and run out. Either a pottery or porcelain kiln will answer, and the fusion should be continued 24 hours; for the more tranquil and continuous it is, the denser is the paste, and the greater its beauty. The following four recipes have afforded good strass:—

| No. I. | | | No. III. | | |
|---|---|---------|------------------|---|---------|
| | | Grains. | | | Grains. |
| Rock crystal | - | 4056 | Rock crystal | - | 3456 |
| Minium | - | 6300 | Minium | - | 5328 |
| Pure potash | - | 2154 | Potash | - | 1944 |
| Borax | - | 276 | Borax | - | 216 |
| Arsenic | - | 12 | Arsenic | - | 6 |
| No. II. | | | No. IV. | | |
| Sand | - | 3600 | Rock crystal | - | 3600 |
| Ceruse of Clichy (pure carbonate of lead) | - | 8508 | Ceruse of Clichy | - | 8508 |
| Potash | - | 1260 | Potash | - | 1260 |
| Borax | - | 360 | Borax | - | 360 |
| Arsenic | - | 12 | | | |

| | | <i>Topaz.</i> | | | Grains. |
|-----|---------------------------------------|---------------|---|---|---------|
| | Very white paste | - | - | - | 1008 |
| | Glass of antimony | - | - | - | 43 |
| | Cassius purple | - | - | - | 1 |
| Or, | Paste | - | - | - | 3456 |
| | Oxide of iron, called saffron of Mars | - | - | - | 36 |

Ruby.

M. Wiéland succeeded in obtaining excellent imitations of rubies, by making use of the topaz materials. It often happened that the mixture for topazes gave only an opaque mass, translucent at the edges, and in thin plates of a red colour. 1 part of this substance being mixed with 8 parts of strass, and fused for 30 hours, gave a fine yellowish crystal-like paste, and fragments of this fused before the blowpipe afforded the finest imitation of rubies. The result was always the same.

The following are other proportions for rubies :—

| | | Grains. |
|--------------------|---|---------|
| Paste | - | 2880 |
| Oxide of manganese | - | 72 |

Emerald.

| | | |
|----------------------------|---|------|
| Paste | - | 4608 |
| Green oxide of pure copper | - | 42 |
| Oxide of chrome | - | 2 |

Sapphire.

| | | |
|-----------------|---|------|
| Paste | - | 4608 |
| Oxide of cobalt | - | 68 |

This mixture should be carefully fused in a luted Hessian crucible, and be left 30 hours in the fire.

Amethyst.

| | | Grains. |
|--------------------|---|---------|
| Paste | - | 4608 |
| Oxide of manganese | - | 36 |
| Oxide of cobalt | - | 24 |
| Purple of Cassius | - | 1 |

Syrian Garnet, or Antient Carbuncle.

| | | Grains. |
|--------------------|---|---------|
| Paste | - | 512 |
| Glass of antimony | - | 256 |
| Cassius purple | - | 2 |
| Oxide of manganese | - | 2 |

Beryl, or Aqua Marina.

| | | Grains. |
|-------------------|---|---------|
| Paste | - | 3456 |
| Glass of antimony | - | 24 |
| Oxide of cobalt | - | 1½ |

In all these mixtures, the substances should be mixed by sifting, fused very carefully, and cooled very slowly, after having been left in the fire from 24 to 30 hours.

M. Lancon has also made many experiments on the same subject. The following are a few of his proportions :—

| <i>Paste.</i> | | Grains. | <i>Amethyst.</i> | | Grains. |
|-------------------------|---|---------|--------------------|---|---------------|
| Litharge | - | 100 | Paste | - | 9216 |
| White sand | - | 75 | Oxide of manganese | - | from 15 to 24 |
| White tartar, or potash | - | 10 | Oxide of cobalt | - | 1 |

Emerald.

| | | |
|--------------------------------------|---|------|
| Paste | - | 9216 |
| Acetate of copper | - | 72 |
| Peroxide of iron, or saffron of Mars | - | 1.5 |

PASTILLE, is the English name of small cones made of gum benzoin, with powder of cinnamon, and other aromatics, which are burned as incense, to diffuse a grateful odour, and conceal unpleasant smells in apartments. See PERFUMERY.

PASTILLE, is the French name of certain aromatic sugared confections; called also *tablettes*.

PATTERN DISPLAYING MACHINE. This is an ingenious contrivance of Messrs. Stewart and Hutcheson, of Paisley, for inventing and displaying patterns of printed goods or worked patterns, in stripes, cheques, and tartans by means of sliding mirrors and coloured glass, and is suitable for manufacturers of textile fabrics of all descriptions.

The advantages of this machine are the facility with which any pattern, or idea of a

pattern, may be set up and displayed, the variety of designs it can produce, and the ease and simplicity of accomplishing them. It is not at all necessary to paint the pattern on paper, after viewing it through the mirrors, as the scales attached show at once the required number of threads of each colour, and how many repeats are necessary for the breadth of the web; and it displays at once not only the repeat, but the whole breadth, and a considerable portion of the length of the cloth at one view.

By this invention, the precise effect of a pattern may be produced in the course of a few minutes, without any expense, multiplied to any extent, and it may be enlarged or diminished at pleasure. The chief novelty, however, of this machine, which was exhibited for its simplicity and the ease of its adaptation, is that the precise effect of the cloth in a finished state is accurately represented, the crisp transparent effect of a silk fabric being truly given, as well as the soft and more opaque effect of a woollen fabric.

This invention is new in principle, being a novel application of coloured glass to useful and essentially practical purposes.

PEARLASH, a commercial form of **POTASH**, which see.

PEARLS (*Perles*, Fr.; *Perlen*, Germ.); are the productions of certain shell-fish. These molluscs are subject to a kind of disease caused by the introduction of foreign bodies within their shells. In this case, their pearly secretion, instead of being spread in layers upon the inside of their habitation, is accumulated round these particles in concentric layers. Pearl consists of carbonate of lime, interstratified with animal membrane.

The oysters whose shells are richest in mother of pearl, are most productive of these highly prized spherical concretions. The most valuable pearl fisheries are on the coast of Ceylon, and at Olmutz in the Persian Gulf, and their finest specimens are more highly prized in the East than diamonds, but in Europe they are liable to be rated very differently, according to the caprice of fashion. When the pearls are large, truly spherical, reflecting and decomposing the light with much vivacity, they are much admired. But one of the causes which renders their value fluctuating, is the occasional loss of their peculiar lustre, without our being able to assign a satisfactory reason for it. Besides, they can be now so well imitated, that the artificial pearls have nearly as rich an appearance as the real.

PEARLS, ARTIFICIAL. These are small globules or pear-shaped spheroids of thin glass, perforated with two opposite holes, through which they are strung, and mounted into necklaces, &c., like real pearl ornaments. They must not only be white and brilliant, but exhibit the iridescent reflectious of mother of pearl. The liquor employed to imitate the pearly lustre, is called the *essence of the east* (*essence d'orient*), which is prepared by throwing into water of ammonia the brilliant scales, or rather the *lamelle*, separated by washing and friction, of the scales of a small river fish, the blay, called in French *ablète*. These scales digested in ammonia, having acquired a degree of softness and flexibility which allow of their application to the inner surfaces of the glass globules, they are introduced by suction of the liquor containing them in suspension. The ammonia is volatilized in the act of drying the globules.

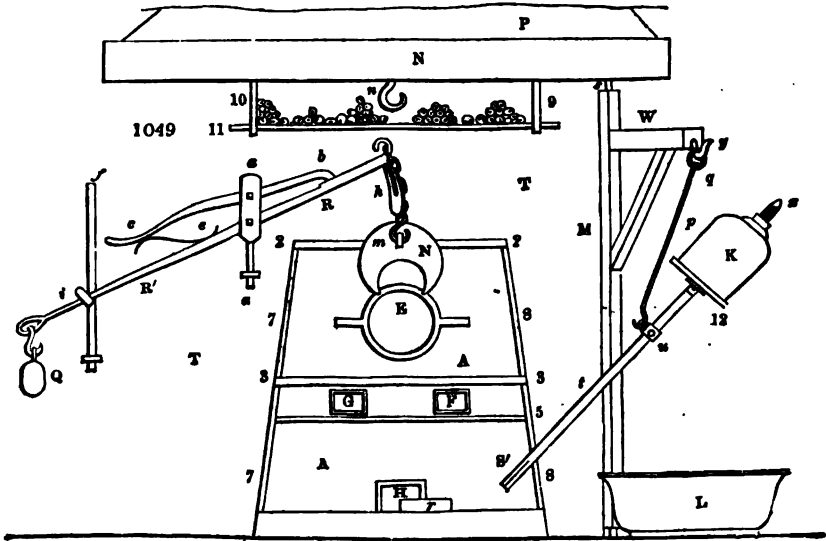
It is said that some manufacturers employ ammonia merely to prevent the alteration of the scales; that when they wish to make use of them, they suspend them in a well clarified solution of isinglass, then pour a drop of the mixture into each bead, and spread it round the inner surface. It is doubtful whether by this method the same lustre and play of colours can be obtained as by the former. It seems moreover to be of importance for the success of the imitation, that the globules be formed of a bluish, opalescent, very thin glass, containing but little potash and oxide of lead. In every manufactory of artificial pearls, there must be some workmen possessed of great experience and dexterity. The French are supposed to excel in this ingenious branch of industry.

False pearls were invented in the time of Catherine de Medicis, by a person of the name of Jaquin. They are made of small globules of glass, blown by the ordinary lamp. The pearly lustre is communicated by introducing by means of a blow-pipe a small quantity of nacreous substances obtained from the surface of the scale of a small fish very common in the Seine and the Rhine, and also in the Thames. This substance preserved with sal ammoniac in a liquid state is commonly sold under the name of "Oriental essence;" after having covered the inside of the pearl with this liquid, a coating of wax is added, which is coloured to the required shade. The manufacture of pearls is principally carried on in the department of the Seine in France. There are also manufactories in Germany and Italy, but to a small extent. In Germany, or rather Saxony, a cheap but inferior quality is manufactured. The globe of glass forming the pearl in inferior ones being very thin, and coated with wax, they break on the slightest pressure. They are known by the name of German fish pearls: Italy also manufactures pearls by a method borrowed from the Chinese; they are known under the name of Roman pearls, and are a very good imitation of natural ones; they have on their outside a coating of the nacreous liquid. The Chinese pearls are made of a kind of gum, and are covered likewise with the same liquid. In the year 1834 a French artisan dis-

covered an opaline glass of a nacreous or pearly colour, very heavy and fusible, which gave to the beads the different weights and varied forms found amongst real pearls: gum instead of wax is now used to fill them, by which they attain a high degree of transparency, and the glassy appearance has been lately obviated by the use of the vapour of hydro-fluoric acid. This acts in such a manner as to deaden the surface, and remove its otherwise glaring look.

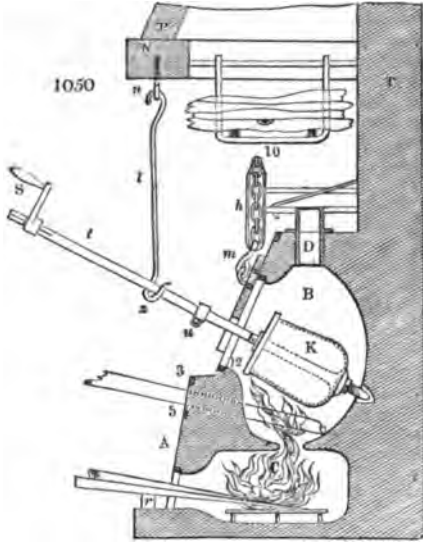
PEARLS ARTIFICIAL, and BEADS. The material out of which these are formed are small glass tubes like those with which thermometers are made. The tubes for the bright red pearls consist of two layers of glass, a white opaque one internally, and a red one externally; drawn from a ball of white enamel, coated in the Bohemian method with ruby-coloured glass, either by dipping the white ball into a pot of red glass, and thus coating it, or by introducing the ball of the former into a cylinder of the latter glass, and then cementing them so soundly together as to prevent their separation in the subsequent pearl processes. These tubes are drawn in a gallery of the glasshouse to 100 paces in length, and cut into pieces about a foot long. These are afterwards subdivided into cylindric portions of equal length and diameter, preparatory to giving them the spheroidal form. From 60 to 80 together are laid horizontally in a row upon a sharp edge, and then cut quickly and dexterously at once by drawing a knife over them. The broken fragments are separated from the regular pieces by a sieve. These cylinder portions are rounded into the pearl shape by softening them by a suitable heat, and stirring them all the time. To prevent them from sticking together, a mixture of gypsum and plumbago, or of ground clay and charcoal, is thrown in among them.

Figs. 1049, 1050 represent a new apparatus for rounding the beads; *fig. 1049* is a front view of the whole; *fig. 1050*, is a section through the middle of the former figure, in the course of its operation. The brick furnace, strengthened with iron bands, 2, 3, 5, 7, 8, has in its interior (see *fig. 1050*.) a nearly egg-shaped space *a*, provided with the following openings: beneath is the fire-hearth, *c*, with a round mouth, and opposite are the smoke flue and chimney, *d*; in the slanting front of the furnace is a large opening, *z*, *fig. 1049*. Beneath are two smaller oblong rectangular orifices, *r*, *a*, which extend somewhat obliquely into the laboratory, *a*. *R* serves for introducing the wood into the fire-place. All these four openings are, as shown in *fig. 1049*., secured from injury by iron mouth pieces. The wood is burned upon an iron or clay bottom piece, *r*. A semi-circular cover, *x*, closes during the operation the large opening, *z*, which at other times remains open. By means of a hook, *m*, and a chain, which rests upon a hollow arch, *k*; the cover *x*, is connected with the front end of the long iron lever, *x*, *x'*. A prop supports at once the turning axis of this lever and the catch, *b*, *c*; the weight, *q*, draws the arm, *a*, down, and thereby holds up *x*; *x* therefore remains open. By



rods on the back wall, τ , τ , the hook, i , in which α' rests, proceeds from f . When α' is raised α sinks. The catch c b , enters with its front tooth into a slanting notch upon the upper edge of α , spontaneously by the action of the spring, e ; whereby the opening, α , is shut. The small door n , rises again with the front arm of the lever by the operation of the weight q of itself, as soon as the catch is released by pressure upon c .

The most important part of the whole apparatus is the drum, x , for the reception and rounding of the bits of glass. It may be made of strong copper, or of hammered



or cast iron, quite open above, and pierced at the bottom with a square hole, into which the lower end of the long rod, t , is exactly fitted, and secured in its place by a screwed collector nut. The blunt point, α , (*fig. 1049*.) rests during the working in a conical iron step of the laboratory, *fig. 1050*. On the mouth of the drum, x , a strong iron ring is fixed, having a bar across its diameter, with a square hole in its middle point, fitted and secured by a pin to the rod t , and turned by its rotation. The vessel α , and its axle, t , are laid in a slanting direction; the axle rests in the upper ring, z , at the lower end of the rod, l , of which the other end is hung to the hook, i , upon the mantel beam, w . On the upper end of t , the handle, s , is fixed for turning round continuously the vessel, α , while the fire is burning in the furnace, the fuel being put not only in its bottom chamber, but also into the holes, τ , o (*fig. 1049*). The fire-wood is made very dry before being used, by piling it in logs upon

the iron bars, 2, 10, 11, under the mantelpiece, as shown in *figs. 1049, 1050*.

After the operation is finished, and the cover, n , is removed, the drum is emptied of its contents, as follows. Upon the axle, t , there is towards x a projection at u . Alongside the furnace (*fig. 1049*.) there is a crane, m , that turns upon the step, s , z , on the ground. The upper pivot turns in a hole of the mantel-beam, w . Upon the perpendicular arm, w , of the crane there is a hook, y , and a ring, g , in which the iron rod, p , is movable in all directions. When the drum is to be removed from the furnace, the crane, with its arm, w , must be turned inwards, the under hook of the rod, p , is to be hung in the projecting piece, u , and the rod, l , is lifted entirely out. After this, by means of the crane, the drum can be drawn with its rod, t , out of the furnace; and through the mobility of the crane, and its parts, p , g , any desired position can be given to the drum. *Fig. 1049* shows how the workman can with his hand applied to s' depress the axle, t , and thereby raise the drum, x , so high that it will empty itself into the pot, r , placed beneath. When left to itself, the drum on the contrary hangs nearly upright upon the crane by means of the rod, p , and may therefore be easily filled again in this position. The manner of bringing it into the proper position in the furnace by means of the crane and the rod, l , is obvious from *fig. 1050*.

The now well-rounded beads are separated from the pulverulent substance with which they were mixed by careful agitation in sieves; and they are polished finally and cleaned by agitation in canvas bags.

PEARL BUTTONS. Pearl-button making is thus practised; the blanks are cut out of the shell by means of a small revolving steel tube, the edge of which is toothed as a saw, after which they are flattened or reduced in thickness by splitting, which is aided by the laminar structure of the shell. At this stage being held in a spring chuck, they are finished on both sides by means of a small tool: the drilling is effected by the revolution of a sharp steel instrument, which acts with great rapidity. Ornamental cuttings are produced by means of small revolving cutters, and the final brilliant polish is given by the friction of rotten-stone and soft soap upon a revolving bench.

PEARLWHITE, is a submuriate of bismuth, obtained by pouring a solution of the nitrate of that metal into a dilute solution of sea salt, whereby a light and very white powder is obtained, which is to be well washed and dried. See **BISMUTH**.

PECTIC ACID (*Acid pectique*, Fr.; *Gallertsaure*, Germ.); so named on account of its jellying property, from *πηκνις*, *coagulum*, exists in a vast number of vegetables. The easiest way of preparing it, is to grate the roots of carrots into a pulp, to express their juice, to wash the marc with rain or distilled water, and to squeeze it well; 50 parts of the marc are next to be diffused through 300 of rain-water, adding by slow degrees a solution of one part of pure potash, or two of bicarbonate. This mixture is to be heated, so as to be made to boil for about a quarter of an hour, and is then to be thrown boiling-hot upon a filter cloth. It is known to have been well enough boiled, when a sample of the filtered liquor becomes gelatinous by neutralizing it with an acid. This liquor contains peotate of potassa, in addition to other matters extricated from the root. The pectate may be decomposed by a stronger acid, but it is better to decompose it by muriate of lime; whereby a pectate of lime, in a gelatinous form, quite insoluble in water, is obtained. This having been washed with cold water upon a cloth, is to be boiled in water containing as much muriatic acid as will saturate the lime. The pectic acid thus liberated, remains under the form of a colourless jelly, which reddens litmus paper, and tastes sour, even after it is entirely deprived of the muriatic acid. Cold water dissolves very little of it; it is more soluble in boiling water. The solution is colourless, does not coagulate on cooling, and hardly reddens litmus paper; but it gelatinizes when alcohol, acids, alkalis, or salts are added to it. Even sugar transforms it, after some time, into a gelatinous state, a circumstance which serves to explain the preparation of apple, cherry, raspberry, gooseberry, and other jellies.

PECTINE, or vegetable jelly, is obtained by mixing alcohol with the juice of ripe currants, or any similar fruit, till a gelatinous precipitate takes place; which is to be gently squeezed in a cloth, washed with a little weak alcohol, and dried. Thus prepared, pectine is insipid, without action upon litmus, in small pieces, semi-transparent, and of a membranous aspect, like isinglass. Its mucilaginous solution in cold water is not tinged blue with iodine. A very small addition of potash, or its carbonate, converts pectine into pectic acid; both of which substances are transformed into mucic and oxalic acids by the nitric.

PELOPIUM; a new metal discovered by H. Rose in the Bavarian tantalite.

PELTRY (*Pelletterie*, Fr.; *Pelzwerk*, Germ.); is nearly synonymous with fur, and comprehends the skins of different kinds of wild animals that are found in high northern latitudes, particularly in the American continent; such as the beaver, bear, moosedeer, marten, mink, sable, woolverin, wolf, &c. When these skins have received no preparation but from the hunters, they are most properly called peltry; but when they have had the inner side tawed or tanned (see **LEATHER**) by an aluminous process, they may then be denominated *fers*.

The scouring or cleaning of peltry is performed in a large cask, or truncated cone laid on its side, and traversed by a revolving shaft, which is furnished with a few rectangular rounded pegs. These are intended to stir round the skins, while they are dusted over with Paris plaster, whitening, or sometimes sand, made as hot as the hand can bear. The bottom of the cask should be grated, to allow the impurities to fall out. The *lustrage*, which the cleansed skins next undergo, is merely a species of dyeing, either topical to modify certain disagreeable shades, or general to impart a more beautiful colour to the fur. Under the article **DYING**, and the several colours, as also **HAIR** and **MOROCCO**, sufficient instructions will be found for dyeing fur. The mordants should be applied pretty hot by a brush, on the hair of the skin, stretched upon a solid table; and after two or three applications, with drying between, the tinctorial infusions may be rubbed on in the same way. The hair must be freed beforehand from all greasiness, by lime water, or a weak solution of carbonate of soda; then well washed. Much nicety, and many successive applications of the dye-stuff, are sometimes requisite to bring out the desired shade.

Under **HAT MANUFACTURE**, I referred to this article for a description of the process of *secretage*, whereby the hairs of rabbit and hare skins are rendered fit for felting. Dissolve 32 parts of quicksilver in 500 of common aquafortis; and dilute the solution with one half or two thirds of its bulk of water, according to the strength of the acid. The skin being laid upon a table with the hair side uppermost, a brush, made with the bristles of the wild boar, is to be slightly moistened with the mercurial solution, and passed over the smooth surface of the hairs with strong pressure. This application must be repeated several times in succession, till every part of the fur be equally touched, and till about two thirds of the length of the hairs be moistened, or a little more should they be rigid. In order to complete this impregnation, the skins are laid together in pairs with the hairy sides in contact, put in this state into the stove-room, and exposed to a heat higher in proportion to the weakness of the mercurial solution. The drying should be rapidly effected, otherwise the concentration of the nitrate will not take due effect in causing the retraction and curling of the hairs.

No other acid, or metallic solution, but the above, has been found to answer the de-

sired purpose of the hatmaker. After the hairs are properly *secreted*, they are plucked off by hand, or shorn off by a machine.

PENCIL MANUFACTURE. (*Crayons, fabriqus de, Fr.*; *Bleistifte, verfertigung, Germ.*) The word pencil is used in two senses. It signifies either a small hair brush employed by painters in oil and water colours, or a slender cylinder of black lead or plumbago, either naked or enclosed in a wooden case, for drawing black lines upon paper. The last sort, which is the one to be considered here, corresponds nearly to the French term *crayon*, through this includes also pencils made of differently coloured earthy compositions. See **CRAYON**.

The best black-lead pencils of this country are formed of slender parallelepipeds, cut out by a saw from sound pieces of plumbago, which have been previously calcined in close vessels at a bright red heat. These parallelepipeds are generally enclosed in cases made of cedar wood, though of late years they are also used alone, in peculiar pencil-cases, under the name of *ever-pointed pencils*, provided with an iron wire and screw, to protrude a minute portion of the plumbago beyond the tubular metallic case, in proportion as it is wanted.

In the year 1795, M. Conté, a French gentleman, well acquainted with the mechanical arts, invented an ingenious process for making artificial black-lead pencils of superior quality, by which he and his successor and son-in-law, M. Humblot, have realized large fortunes.

Pure clay, or clay containing the smallest proportion of calcareous or siliceous matter, is the substance which he employed to give aggregation and solidity, not only to plumbago dust, but to all sorts of coloured powders. That earth has the property of diminishing in bulk, and increasing in hardness, in exact proportion to the degree of heat it is exposed to, and hence may be made to give every degree of solidity to crayons. The clay is prepared by diffusing it in large tubs through clear river water, and letting the thin mixture settle for two minutes. The supernatant milky liquor is drawn off by a syphon from near the surface, so that only the finest particles of clay are transferred into the second tub, upon a lower level. The sediment which falls very slowly in this tub, is extremely soft and plastic. The clear water being run off, the deposit is placed upon a linen filter, and allowed to dry. It is now ready for use.

The plumbago must be reduced to a fine powder in an iron mortar, then put into a crucible, and calcined at a heat approaching to whiteness. The action of the fire gives it a brilliancy and softness which it would not otherwise possess, and prevents it from being affected by the clay, which it is apt to be in its natural state. The less clay is mixed with the plumbago, and the less the mixture is calcined, the softer are the pencils made of it; the more clay is used the harder are the pencils. Some of the best pencils made by M. Conté, were formed of two parts of plumbago and three parts of clay; others of equal parts. This composition admits of indefinite variations, both as to the shade and hardness; advantages not possessed by the native mineral. While the traces may be made as black as those of pure plumbago, they have not that glistening aspect which often impairs the beauty of black-lead drawing. The same lustre may, however, be obtained by increasing the proportion of powdered plumbago relatively to the clay.

The materials having been carefully sifted, a little of the clay is to be mixed with the plumbago, and the mixture is to be triturated with water into a perfectly uniform paste. A portion of this paste may be tested by calcination. If on cutting the indurated mass, particles of plumbago appear, the whole must be further levigated. The remainder of the clay is now to be introduced, and the paste is to be ground with a muller upon a porphyry slab, till it be quite homogeneous, and of the consistence of thin dough. It is now to be made into a ball, put upon a support, and placed under a bell glass inverted in a basin of water, so as to be exposed merely to the moist air.

Small grooves are to be made in a smooth board, similar to the pencil parallelepipeds, but a little longer and wider, to allow for the contraction of volume. The wood must be boiled in grease, to prevent the paste from sticking to it. The above described paste being pressed with a spatula into these grooves, another board, also boiled in grease, is to be laid over them very closely, and secured by means of screw-clamps. As the atmospheric air can get access only to the ends of the grooves, the ends of the pencil pieces become dry first, and by their contraction in volume get loose in the grooves, allowing the air to insinuate further, and to dry the remainder of the paste in succession. When the whole piece is dried, it becomes loose, and might be turned out of the grooves. But before this is done, the mould must be put into an oven moderately heated, in order to render the pencil-pieces still drier. The mould should now be taken out, and emptied upon a table covered with cloth. The greater part of the pieces will be entire, and only a few will have been broken, if the above precautions have been duly observed. They are all, however, perfectly straight, which is a matter of the first importance.

In order to give solidity to these pencils, they must be set upright in a crucible till

it is filled with them, and then surrounded with charcoal powder, fine sand, or sifted wood ashes. The crucible, after having a luted cover applied, is to be put into a furnace, and exposed to a degree of heat regulated by the pyrometer of Wedgwood; which degree is proportional to the intended hardness of the pencils. When they have been thus baked, the crucible is to be removed from the fire, and allowed to cool with the pencils in it.

Should the pencils be intended for drawing architectural plans, or for very fine lines, they must be immersed in melted wax or suet nearly boiling hot, before they are put into the cedar cases. This immersion is best done by heating the pencils first upon a grid-iron, and then plunging them into the melted wax or tallow. They acquire by this means a certain degree of softness, are less apt to be abraded by use, and preserve their points much better.

When these pencils are intended to draw ornamental subjects with much shading, they should not be dipped as above.

Second process for making artificial pencils, somewhat different from the preceding. — All the operations are the same, except that some lamp-black is introduced along with the plumbago powder and the clay. In calcining these pencils in the crucible, the contact of air must be carefully excluded, to prevent the lamp-black from being burned away on the surface. An indefinite variety of pencils, of every possible black tint, may thus be produced, admirably adapted to draw from nature.

Another ingenious form of mould is the following:

Models of the pencil-pieces must be made in iron, and stuck upright upon an iron tray, having edges raised as high as the intended length of the pencils. A metallic alloy is made of tin, lead, bismuth, and antimony, which melts at a moderate heat. This is poured into the sheet-iron tray, and after it is cooled and concreted, it is inverted, and shaken off from the model bars, so as to form a mass of metal perforated throughout with tubular cavities, corresponding to the intended pencil-pieces. The paste is introduced by pressure into these cavities, and set aside to dry slowly. When nearly dry, the pieces get so much shrunk that they may be readily turned out of the moulds upon a cloth table. They are then to be completely desiccated in the shade, afterwards in a stove-room, next in the oven, and lastly ignited in the crucible, with the precautions above prescribed.

M. Conté recommends the hardest pencils of the architect to be made of lead melted with some antimony and a little quicksilver.

In their further researches upon this subject, M. Conté and M. Humblot found that the different degrees of hardness of crayons could not be obtained in a uniform manner by the mere mixture of plumbago and clay in determinate doses. But they discovered a remedy for this defect in the use of saline solutions, more or less concentrated, into which they plunged the pencils, in order to modify their hardness, and increase the uniformity of their texture. The non-deliquescent sulphates were preferred for this purpose; such as sulphate of soda, &c. Even syrup was found useful in this way.

Messrs. Stevens and Wylder's pencils, pens, and pen holders. — Messrs. Stevens & Wylder obtained a patent in June, 1850, for certain improvements, in which they claim,

1. (In respect of ever pointed pencils.) The employment of an internal helix in lieu of a propelling screw, by means of which a length of black lead, chalk, or other marking materials may be propelled nearly the whole length of the pencil.

2. (With reference to pens.) The application of gutta percha to metal pens, between the shoulder and the nibs, the metal having been first reduced in thickness, either by grinding or otherwise, for the purpose of obtaining greater flexibility. 2ndly. The construction of barrel and other pens in metal, to be used with fountain pen holders, having the barrel placed the reverse way, or above instead of below the nibs.

3. (With respect to penholders.) 1st. The use and application of glass to telescopic and other fountain holders, whereby the ink is kept from contact with metal until it reaches the pen. (Query, Has not this been anticipated by Mr. Thomson's patent?) 2ndly. The adaptation of a band of flexible material to fountain holders, for the purpose of facilitating the flow of ink to the pen, such band being placed around a part of the tube, in which air holes or openings have been previously made.

PENS, STEEL. The best metal, made from Dannemora or hoop (t) iron, is selected and laminated into slips about 3 feet long, and 4 inches broad, of a thickness corresponding to the desired stiffness and flexibility of the pens. These slips are subjected to the action of a stamping-press, somewhat similar to that for making buttons. (See **BUTTON** and **PLATED WARE**.) The point destined for the nib is next introduced into an appropriate gauged hole of a little machine, and pressed into the semi-cylindrical shape; where it is also pierced with the middle slit, and the lateral ones, provided the latter are to be given. The pens are now cleaned, by being tossed about among each other, in a tin cylinder, about 3 feet long, and 9 inches in diameter; which is suspended at each end upon joints to two cranks, formed one on each of two shafts. The cylinder, by the rotation of a fly-

wheel, acting upon the crank-shafts, is made to describe such revolutions as agitate the pens in all directions, and polish them by mutual attrition. In the course of 4 hours several thousand pens may be finished upon this machine.

When steel pens have been punched out of the softened sheet of steel by the appropriate tool, fashioned into the desired form, and hardened by ignition in an oven and sudden quenching in cold water, they are best tempered by being heated to the requisite spring elasticity in an oil bath. The heat of this bath is usually judged of by the appearance to the eye; but this point should be correctly determined by a thermometer, according to the scale (see *STEEL*); and then the pens would acquire a definite degree of flexibility or stiffness, adapted to the wants and wishes of the consumers. They are at present tempered too often at random.

Gillott, Joseph, Victoria Works, Birmingham, Inventor and Manufacturer. Specimens of metallic pens. Steel pen making may be briefly described as follows: The steel is procured at Sheffield; it is cut into strips, and the scales removed by immersion in pickle composed of dilute sulphuric acid. It is passed through rollers, by which it is reduced to the necessary thickness; it is then in a condition to be made into pens, and is for this purpose passed into the hands of a girl, who is seated at a press, and who by means of a bed and a punch corresponding speedily cuts out the blank. The next stage is piercing the hole which terminates the slit and removing any superfluous steel likely to interfere with the elasticity of the pen; at this stage they are annealed in quantities in a muffle, after which by means of a small stamp the maker's name is impressed upon them. Up to this stage the future pen is a flat piece of steel: it is then transferred to another class of workers, who by means of the press make it concave, if a nib, and form the barrel, if a barrel pen. Hardening is the next process: to effect this a number of pens are placed in a small iron box and introduced into a muffle; after they become of a uniform deep red, they are plunged into oil; the oil adhering is removed by agitation in circular tin barrels. The process of tempering succeeds; and finally the whole are placed in a revolving cylinder with sand, pounded crucible, or other cutting substances, which finally brightens them to the natural colour of the material. The nib is ground with great rapidity by a girl who picks it up, places it in a pair of suitable pliers, and finishes it with a single touch on a small emery wheel. The pen is now in a condition to receive the slit, and this is also done by means of a press; a chisel or wedge with a flat side is fixed to the bed of the press; the descending screw has a corresponding chisel cutter, which passes down with the minutest accuracy: the slit is made; and the pen is completed. The last stage is colouring brown or blue; this is done by introducing the new pens into a revolving metal cylinder, under which is a charcoal stove, and watching narrowly when the desired tint is arrived at. The brilliancy is imparted by means of lac dissolved in naphtha; the pens are immersed in this, and dried by heat. Then follow the counting and selecting. Women are mostly employed in the manufacture, with skilled workmen to repair and set the tools. This exhibitor employs upwards of five hundred hands, of which four-fifths are women. The manufactory has been established upwards of thirty years, and has been the means of introducing many improvements in the manufactory.

Wiley, W. E. & Co., 34 Great Hampton Street, Birmingham—Manufacturer. Specimens of gold, palladium, gold and silver, and silver pens, pointed with the native alloys of iridium and osmium, the hardest of metals.

These pens, being formed of metals not acted on by the ink, appear almost indestructible; their permanence in use is further maintained by the attachment to the point, by soldering, of a minute portion of the metals named, which are extremely hard and durable.

Hincks, Wells, & Co., Buckingham Street, Birmingham—Manufacturers. Patent self-acting cutting, piercing, and raising pen machine. The ordinary presses are worked by hand. The self-acting machines are driven by steam; they cut, pierce, and slide slit two pens at one stroke, performing six processes at once.

Specimens of lilliputian pens complete, intended to show the skill of the tool cutter and the perfection of the machinery employed. A gross of the smallest weighs less than 34 grains, and can be contained in a barcelona nutshell.

Specimens of finished pens. Steel in its rough state, and after it has passed through the rolling-mill; scrap steel from which the pens are cut; pens cut and pierced. The other processes exhibited in the finished pen.

Specimens of pierced pens, to show the modern improvements in the art of tool-cutting.

PEPPER. (*Poire*, Fr.; *Pfeffer*, Germ.). Black pepper is composed, according to M. Pelletier, of the vegetable principle, *piperine*, of a very acrid concrete oil, a volatile balsamic oil, a coloured gummy matter, an extractive principle analogous to legumine, malic and tartaric acids, starch, bassorine, ligneous matter, with earthy and alkaline salts in small quantity. Cubeb pepper has nearly the same composition.

The unripe grains or corns are known under the name of black pepper; the ripe ones, deprived of their epidermis, constitute white pepper. The latter are very generally bleached by steeping for a little while in a solution of chloride of lime, subsequent washing and drying; a process which improves their aspect, but not their flavour. I was recently led to examine the nature of this substance somewhat minutely, from being called professionally to investigate a sample of ground white pepper belonging to an eminent spice-house in the city of London, which pepper had been seized by the Excise on the charge of its being adulterated, or mixed with some foreign matter, contrary to law. I made a comparative analysis of that pepper and of genuine white-pepper corns, and found both to afford like results: viz. in 100 grains, a trace of volatile oil, in which the aroma chiefly resides; about $8\frac{1}{2}$ grains of pungent resin, containing a small fraction of a grain of piperine; about 60 grains of starch, with a little gum, and nearly 30 grains of matter insoluble in hot and cold water, which may be reckoned lignine. The two chemists in the service of the Excise made oath before the court of judicature, that the said pepper contained a notable proportion of sago, even to the amount of fully 10 per cent.; grounding their judgment upon the appearance of certain rounded particles in the pepper, and of the deep blue colour which these assumed when moistened with iodine water. No allegation could be more frivolous. Bruised corns of genuine white pepper certainly acquire as deep a tint with iodine as any species of starch whatever. But the characters of sago, optical and chemical, are so peculiar, as to render the above surmise no less preposterous, than the prosecution of respectable merchants, for such a cause, was unjustifiable. A particle of sago appears in the microscope, by reflected light, to be a spherule of snow, studded round with brilliants; whereas the rounded particles of the seized pepper seem to be amorphous bits of grey clay. Had the pepper been adulterated with such a quantity of sago, or anything else, as was alleged, it could not have afforded me, by digestion in alcohol, as much of the spicy essence as the bruised genuine pepper-corns did.

Moreover, sago steeped for a short time in cold water, swells and softens into a pulpy consistence, whereas the particles of the seized pepper, rounded by attrition in the mill, retain, in like circumstances, their hardness and dimensions. Sago, being pearled by heating and stirring the fine starch of the sago palm in a damp state, upon iron or other plates, acquires its peculiar somewhat loose aggregation and brilliant surface; while, in pepper, the starchy constituent is compactly condensed, and bound up with its ligneous matter.

The Excise laws are sufficiently odious and oppressive in themselves without being aggravated by the servile sophistry of pseudo-science.

Four pounds of black pepper yield only about one ounce of piperine, or one 696th part. It is an insipid crystalline substance, insoluble in water, but very soluble in boiling alcohol, and is extracted at first along with the resin, which may be separated from it afterwards, by potash.

| | Imported. | Retained for Consumption. | Exported. | Duty received. |
|------|-----------|---------------------------|-----------|----------------|
| | lbs. | lbs. | lbs. | £ |
| 1850 | 8,082,319 | 3,174,425 | 3,727,183 | 83,324 |
| 1851 | 3,996,496 | 3,308,402 | 2,709,755 | 86,729 |

Duty 6d. per lb.

PERCUSSION CAPS, Patent. The total manufacture of percussion caps for sporting guns in Europe may be estimated at 1,300,000,000 yearly. Some idea of the importance of this article may be formed from the quantity of copper requisite for its production, viz. 396,000 lbs. weight. The great advantages of the percussion principle have been so generally acknowledged, that within the short space of 20 years all kinds of guns with flint-locks have been abandoned, and the percussion system has likewise been extended to muskets for the army. The percussion caps exhibited are stated to be remarkable for accuracy and equality of bore, for the malleability of the copper, and superior quality of the powder. The percussion caps coated with varnish exhibited may remain in water for 72 hours and more without losing their power of immediately igniting the powder.

Nipples (*pistons*) hermetically closed, a new invention which prevents any moisture from penetrating between the percussion caps and the nipple, and thus preserves the sportsman's powder perfectly dry.

PERFUMERY, ART OF (*Parfumerie, Fr.; Wohlriechende-kunst, Germ.*); consists in the preparation of different products, such as fats or pommades, essential oils, distilled spirits, pastes, pastilles and essences.

Fats ought to be pounded in a marble mortar, without addition of water, till all the membranes be completely torn; then subjected to the heat of a water-bath in a proper vessel. The fat soon melts, and the albumen of the blood coagulating, carries with it all the foreign substances; the liquid matter should be skimmed, and passed through a canvas filter.

Of pommades by infusion. — Rose, orange-flower, and cassia. Take 334 pounds of hog's lard, and 166 of beef suet. These 500 pounds are put into a pan called *bugadier*; and when melted, 150 pounds of rose-leaves nicely plucked are added, taking care to stir the mixture every hour. The infusion thus prepared is to remain at rest for 24 hours; at the end of this time, the pommade is again melted, and well stirred to prevent its adherence to the bottom of the melting-pan. The mass is now to be poured out into canvas, and made into rectangular bricks or loaves, which are subjected to a press, in order to separate the solid matter from the soft pommade. These brick-shaped pieces being put into an iron-bound barrel perforated all over its staves, the pommade is to be allowed to exude on all sides, and flow down into a copper vessel placed under the trough of the press. This manipulation should be repeated with the same fat ten or twelve times; or in other words, 3000 pounds of fresh rose-leaves should be employed to make a good pommade.

The pommade of orange-flowers is made in the same manner, as also the pommade of cassia.

Of pommades without infusion. — Jasmin, tuberose, jonquil, narcissus, and violet.

A square frame, called *time*, is made of four pieces of wood, well joined together, 2 or 3 inches deep, into which a pane of glass is laid, resting upon inside ledges near the bottom. Upon the surface of the pane the simple pommade of hog's lard and suet is spread with a pallet knife; and into this pommade the sweet-scented flowers are stuck fresh in different points each successive day, during two or three months, till the pommade has acquired the desired richness of perfume. The above described frames are piled closely over each other. Some establishments at *Grasse* possess from 3000 to 4000.

Of oils. — Rose, orange-flower, and cassia oils, are made by infusion, like the pommades of the same perfumes; taking care to select oils perfectly fresh. As to those of jasmin, tuberose, jonquil, violet, and generally all delicate flowers, they are made in the following manner. Upon an iron frame, a piece of cotton cloth is stretched, imbued with olive oil of the first quality, and covered completely with a thin bed of flowers. Another frame is similarly treated, and in this way a pile is made. The flowers must be renewed till the oil is saturated with their odour. The pieces of cotton cloth are then carefully pressed to extrude the oil. This last operation requires commonly 7 or 8 days.

Of distillation. — The essential oils or essences, of which the great manufacture is in the south of France, are of rose, neroli, lavender, lemon thyme, common thyme, and rosemary. For the mode of distilling the essential oils, see OILS ESSENTIAL.

The essence of roses being obtained in a peculiar manner, I shall describe it here. Put into the body of a still 40 pounds of roses, and 60 quarts of water; distil off one half of the water. When a considerable quantity of such water of the first distillation is obtained, it must be used as water upon fresh rose-leaves; a process of repetition to be carried to the fifth time. In the distillation of orange-flower to obtain the essence of neroli, the same process is to be followed; but if orange-flower water merely be wanted, then it is obtained at one distillation, by reserving the first fifth part of water that comes over. What is called the essence of *petit-grain*, is obtained by distilling the leaves of the orange shrub. The essences of lavender, thyme, &c., present nothing peculiar in their mode of extraction.

OF SCENTED SPIRITS.

From oil of rose, orange, jasmin, tuberose, cassia, violet, and other flowers.

Into each of three digesters, immersed in water-baths, put 25 lbs. of any one of these oils, and pour into the first digester 25 quarts of spirit of wine; agitate every quarter of an hour during three days, and at the end of this period, draw off the perfumed

| <i>Esprit de suave.</i> | <i>Spirit of Cytherea.</i> |
|--|----------------------------|
| 7 Eng. qrts. of spirit of jasmin, 3d operation | 1 quart spirit of violets, |
| 7 — cassia, — | 1 — jasmine 2d operation. |
| 3 — wine, — | 1 — tuberose, |
| 2 — tuberose, — | 1 — clove gilly flower. |
| 1 ½ ounce essence of cloves. | 1 — roses, 2d operation. |
| ½ ounce fine neroli. | 1 — Portugal. |
| 1 ½ ounce essence of bergamote. | 2 — orange-flower water. |
| 8 ounces essence of musk, 2d infusion. | |
| 3 quarts rose water. | |

spirit, and pour it into the second digester; then transfer it after 3 days into the third digester, treating the mixture in the same way; and the spirit thus obtained will be perfect. The digesters must be carefully covered during the progress of these operations. On pursuing the same process with the same oil and fresh alcohol, essences of inferior qualities may be obtained, called No. 2, 3, and 4.

Some perfumers state that it is better to use highly scented pommades than oils; but there is probably little difference in this respect.

Spirit of flowers of Italy.

| | | | | | | |
|---|--------------------------|---------------|----|---|--------------------------|----------------------|
| 2 | quarts spirit of jasmin, | 2d operation. | | 2 | quarts spirit of cassia, | 2d operation. |
| 2 | — | roses | — | 1 | — | orange-flower water. |
| 8 | — | oranges, | 3d | — | — | — |

The above spirits mark usually 28 alcometric degrees of Gay Lussac. See ALCOHOL.

POMMADES.

No less than 20 scented pommades are distinguished by the perfumer of Paris. The essences commonly employed in the manufacture of pommades, are those of bergamote, lemons, *cedrat*, *limette* (sweet lemon), Portugal, rosemary, thyme, lemon thyme, lavender, marjoram, and cinnamon.

The following may serve as an example :

Pommade a la vanille, commonly called Roman.

| | |
|----|---------------------------------------|
| 12 | pounds of pommade à la rose, |
| 3 | — oil à la rose, |
| 1 | — vanilla, first quality, pulverized, |
| 6 | ounces bergamote. |

The pommade being melted at the heat of a water-bath, the vanilla is to be introduced with continual stirring for an hour. The mixture is left to settle during two hours. The pommade is then to be drawn off, and will be found to have a fine yellow colour, instead of the brown shade which it commonly has.

In making odoriferous extracts and waters, the spirits of the flowers prepared by macerating the flowers in alcohol should be preferred to their distillation, as forming the foundation of good perfumery. The specific gravity of these spirits should be always under 0.88.

Extract of nosegay (bouquet).

| | | |
|---|--------------------------|---------------------------------------|
| 2 | quarts spirit of jasmin, | 1st operation. |
| 2 | — | extract of violets, |
| 1 | — | spirit of cassia, 1st |
| 1 | — | roses - 1st |
| 1 | — | orange, - 1st |
| 1 | — | extract of clove gilly flower. |
| 4 | drms. | of flowers of benzoin (benzoic acid). |
| 8 | ounces | of essence of amber, 1st infusion. |

Extract of peach blossoms.

| | | |
|---|---------------------------------------|---------------|
| 6 | quarts of spirits of wine. | |
| 6 | pounds of bitter almonds. | |
| 2 | quarts of spirits of orange-flower, | 2d operation. |
| 4 | drachms of essence of bitter almonds. | |
| 4 | drachms of balsam of Peru. | |
| 4 | ounces of essence of lemons. | |

Eau de Cologne.

Two processes have been adopted for the preparation of this perfume, distillation and infusion; the first of which, though generally abandoned, is, however, the preferable one. The only essences which should be employed, and which have given such celebrity to this water, are the following; bergamote, lemon, rosemary, Portugal, neroli. The whole of them ought to be of the best quality, but their proportions may be varied according to the taste of the consumers.

Thirty different odours are enumerated by perfumers; the three following recipes will form a sufficient specimen of their combinations.

Honey-water.

| | | |
|----|----------------------------|-------------------------------------|
| 6 | quarts of spirit of roses, | 3d operation. |
| 3 | do. | jasmin. |
| 3 | do. | spirits of wine. |
| 3 | ounces | essence of Portugal. |
| 4 | drachms | flowers of benzoin. |
| 12 | ounces | of essence of vanilla, 3d infusion. |
| 12 | do. | musk do. |
| 3 | quarts | good orange-flower water. |

Eau de mille fleurs.

| | | |
|----|----------------------------|-----------------------|
| 18 | quarts of spirits of wine. | |
| 4 | ounces | balsam of Peru. |
| 8 | do. | essence of bergamote. |
| 4 | do. | cloves. |
| 1 | do. | ordinary neroli. |
| 1 | do. | thyme. |
| 8 | do. | musk, 3d infusion. |
| 4 | quarts | orange-flower water. |

Eau de mousseline.

| | |
|--|---|
| 2 quarts spirit of roses, 3d infusion. | 2 ounces essence of vanilla, 3d infusion. |
| 2 do. jasmin, 4th do. | 2 do. musk, do. |
| 1 do. clove gilly flower. | 4 drachms of saunders wood. |
| 2 do. orange flower, 4th do. | 1 quart of orange-flower water. |

Almond pastes.

These are, gray, sweet white, and bitter white.

The first is made either with the kernels of apricots, or with bitter almonds. They are winnowed, ground, and formed into loaves of 5 or 6 pounds weight, which are put into the press in order to extract their oil; 300 pounds of almonds affording about 130 of oil. The pressure is increased upon them every two hours during three days; at the end of which time the loaves or cakes are taken out of the press to be dried, ground, and sifted.

The second paste is obtained by boiling the almonds in water till their skins are completely loosened; they are next put into a basket, washed and blanched; then dried, and pressed as above.

The third paste is prepared like the second, only using bitter almonds.

Liquid almond pastes, such as those of the rose, orange, vanilla, and nousegay.—The honey paste is most admired. It is prepared as follows:—

| | |
|---------------------------|----------------------------------|
| 6 pounds of honey. | 12 pounds oil of bitter almonds. |
| 6 do. white bitter paste. | 26 yolks of eggs. |

The honey should be heated apart and strained; 6 pounds of almond paste must then be kneaded with it, adding towards the conclusion, alternately, the quantity of yolks of eggs and almond oil indicated.

Pastilles à la rose, orange flower, and vanilla.

| <i>Pastilles à la rose.</i> | | <i>Pastilles of orange flower.</i> | |
|----------------------------------|--|------------------------------------|--|
| 12 ounces of gum. | | 12 ounces of gum galbanum. | |
| 12 do. olibanum, in tears. | | 12 do. olibanum, in tears. | |
| 12 do. storax, do. | | 12 do. storax, do. | |
| 8 do. nitre. | | 8 do. nitre. | |
| 16 do. powder of pale roses. | | 1 pound of pure orange powder. | |
| 3 pounds 14 do. charcoal powder. | | 3 do. 14 ounces charcoal powder. | |
| 1 do. essence of roses. | | 1 ounce superfine neroli. | |

Pastilles à la vanilla.

| | |
|----------------------------|-------------------------------------|
| 12 ounces of gum galbanum. | 16 ounces of powder of vanilla. |
| 12 do. olibanum, in tears. | 3 pounds 14 ounces charcoal powder. |
| 12 do. storax do. | 4 drms. essence of cloves. |
| 8 do. nitre. | 8 ounces do. vanilla, 1st infusion. |
| 8 do. cloves. | |

The above mixture in each case is to be thickened with 2 ounces of gum tragacanth dissolved in 2 pints of rose-water. It is needless to say that the ingredients of the mixture should be impalpable powders.

Scented cassolettes.

| | |
|-------------------------------------|---|
| 8 pounds of black amber (ambergis). | 1 ounce essence of roses. |
| 4 do. rose powder. | 1 do. gum tragacanth. |
| 2 ounces of benzoïn. | A few drops of the oil of sanders wood. |

These ingredients are pulverized, and made into a cohesive paste with the gum.

ESSENCES BY INFUSION.

Essence of musk.

| |
|---|
| 5 ounces of musk from the bladder, cut small. |
| 1 do. civet. |
| 4 quarts of spirit of ambrette (purple sweet sultan). |

The whole are put into a mattress, and exposed to the sun for two months during the hottest season of the year. In winter, the heat of a water-bath must be resorted to.

Essence of vanilla.

3 pounds of vanilla in branches, 1st quality, cut small.
 4 quarts spirit of ambrette.
 2 drachms of cloves.
 $\frac{1}{2}$ do. musk from the bladder.

The same process must be followed as for the essence of musk.

Essence of ambergris.

| | | |
|---------------------------|--|---------------------------------|
| 4 ounces of ambergris. | | 8 quarts of spirit of ambrette. |
| 2 ounces of bladder musk. | | Treat as above. |

Spirit of ambrette (purple sweet sultan).

25 pounds of ambrette are to be distilled with 25 quarts of spirits of wine, adding 12 quarts of water, so as to be able to draw off the 25 quarts.

Artificial Essences of Fruits in the Exhibition. The artificial production of aromatic oils, for industrial objects, can only be traced back a few years. Young, however, as this manufacture is, it appears, nevertheless, to have been in the hands of several distillers, by whom a very considerable amount has been produced. Upon this point the jury became fully convinced by their investigations in this department; both in the English and in the French divisions of the Exhibition a large selection of these chemical perfumeries were to be found, the comparison of which at the same time with other aromatic preparations was satisfactorily illustrated. Most of these oils are poisonous in small quantities, so that in very few instances can their action be asserted without fresh investigations.

The commonest of these preparations was the pear-oil (Birnö), a favourite fluid, which, by examination, is proved to be an alcoholic solution of acetate of the oxide of amyle. As the author had not sufficient of this satisfactorily to determine its composition by its combustion, he mixed it with potash, by which means fusel oil was immediately liberated, and the acetic acid was separated in the form of salt of silver, of which 0.3089 grammes gave 0.1994 grammes silver; the percentage of silver in the acetate being theoretically 64.68, by experiment 64.55. The acetate of oxide of amyle made according to the usual process (1 part sulphuric acid, 1 part fusel oil, and 2 parts of acetate of potash), presents a strong fruity odour, and by the addition of about 6 parts of alcohol, yields the flavour of jargonelle pear. Upon closer inquiry of the manufacturers of this substance the author found that it was produced in very considerable quantities (by some between 15 and 20 lbs. weekly). In England it is extensively employed in flavouring "pear-drops," which have almost superseded the common "barley-sugar drops."

Next to the "pear" oil, figures *Apple oil*, which experiment has shown to be nothing more than a valerianate of oxide of amyle, which yields an insupportable odour of rotten apples, pervading the laboratory where valerianic acid is produced. If the crude product of distillation be treated with a solution of potash, the valerianic acid is removed and the ether is retained: the addition to this of 5 or 6 times its volume of alcohol gives off an agreeable odour of apples.

The essence, however, which was observed to be in the greatest abundance was the "*Pine Apple oil*," which is simply a butyrate of oxide of ethyle. This composition, like the two preceding, yields its flavour on the addition of alcohol. The butyric ether, which in Germany is added to inferior sorts of rum, for the purpose of imparting a flavour to a peculiar kind of drink (pine apple ale), is seldom prepared for this purpose from pure butyric acid, but from the saponified acid, and the distillation of the soap with concentrated sulphuric acid and alcohol (vide *Annalen der Chemie und Pharmacie*, xlix. 359.) The fluid thus obtained contains other kinds of ether besides butyric ether, but may, without these, be employed for flavouring. The analysis of this ether by means of potash and a salt of silver, gave 0.4404 gr. of salt of silver; 0.2437 silver; the percentage of silver in its butyrate being, theoretically, 55.38, experimentally, 55.33.

The so-called *Cognac oil* and *Grape oil* were contributed to both the English and French departments. They are most frequently employed for giving the cognac flavour to brandies. The grape oil consists of a compound of amyle dissolved in alcohol, then set free by the addition of concentrated sulphuric acid; the oil of sulphate of amyle is then freed from alcohol by washing with water. Analysed by means of a salt of barium 1.2690 gr. amyl-sulphate of baryta gave 0.5815 gr. of sulphate of baryta, equal to 45.82 per cent. of sulphate of baryta. According to Cahours, and again more lately, according to Kekule, the analysis of amyl-sulphate of baryta with 2 eq. of water, contains 49.95 per cent. of sulphate of baryta. It is certainly remarkable, as has been observed, that we have here a body, which is most carefully excluded from brandy.

on account of its intolerable odour, employed again under another form to give it flavour.

The next object of attention is the *artificial oil of bitter almonds*. When Mitscherlich, in 1834, discovered nitro-benzule, he did not foresee the great amount in which this body would be found in an Industrial Exhibition. It is true he had observed the remarkable similarity of its odour to that of oil of bitter almonds, but then the only source whence the nitro-benzule could be obtained, viz., from the oil of compressed gases, and the distillation of benzoic acid, were too costly to admit of the idea of its employment as a substitute for oil of bitter almonds. It remained for the author, in 1845, to detect the presence of benzule in the transformation of coal tar; and in 1849, Mansfield (*Chemical Society's Quarterly Journal*, i., 244.; *Annalen*, lxi. 162.) showed that it could be obtained with facility in considerable quantities from coal tar. The Great Exhibition has shown that this statement has not been lost sight of. In the French department of perfumery, it was met with under the designation of artificial oil of bitter almonds, and under the fantastic name of essence of mirbane, varieties of the oil which, on examination, were found to be more or less pure nitro-benzule. In London it is used in large quantities. Messrs. Mansfield's simple apparatus for its preparation is thus described:—A large glass worm is used, the upper end of which is bifurcated, and forms two tubes of a funnel shape; into one of these funnels concentrated nitric acid is poured, in the other the benzule is placed (and for this purpose it is not required to be absolutely pure). The two bodies, therefore, meet at the point of junction of these two tubes, the compound is cooled by its course through the windings of the worm, and requires only to be washed with water or diluted solution of carbonate of soda, and it is then fit for use. Although nitro-benzule has an odour so closely resembling oil of bitter almonds, a difference may be detected by an experienced nose. It is, however, very generally employed in scenting soaps, in confectionery, and for culinary purposes. For the last named purpose it has the advantage of not containing hydrocyanic acid.

Besides the preceding, many other substances of analogous nature were exhibited, but they were of too complicated characters to be satisfactorily examined in the small quantities to be met with. In many of these essences, there was, however, a great similarity of aroma.

PERFUMERY, INDIAN. The natives place on the ground a layer of the scented flowers, about 4 inches thick and 2 feet square; cover them with a layer 2 inches thick of *Tel* or Sesamum seed wetted; then lay on another 4 inch bed of flowers, and cover this pile with a sheet, which is pressed down by weights round the edges. After remaining in this state for 18 hours, the flowers are removed and replaced by a similar fresh layer, and treated as before; a process which is repeated a third time if a very rich perfumed oil be required. The sesamum seeds thus imbued with the essential oil of the plant, whether jasmine, Bela, or Chumbul, are placed in their swollen state in a mill, and subjected to strong pressure, whereby they give out their bland oil strongly impregnated with the aroma of the particular flower employed. The oil is kept in prepared skins called *dubbers*, and is largely used by the Indian women. The attar of roses is obtained by distillation at a colder period of the year.

PERRY, is the fermented juice of pears, prepared in exactly the same way as **CYDER**.

PERSIAN BERRIES. See **BERRIES, PERSIAN**.

PERSONAL CLOTHING. The title of the class will suggest the multifarious objects which fall naturally within its comprehensive limits. The sub-classes are as follows:—A. hats, caps, and bonnets of various materials; B. hosiery, of cotton, woollen, and silk; C. gloves of leather and other materials; D. boots, shoes, and lasts; E. under-clothing; F. upper clothing.

The manufactories of hosiery, straw plait, and boots and shoes, have a local establishment in this country, which is deserving of attention; that of hosiery is principally confined to Derby, Nottingham, and Leicester. Cotton hosiery is chiefly made in Nottingham, as also is the silk hosiery; the latter being likewise largely conducted in Derby. Woollen hosiery is most extensively produced in Leicestershire. The statistics of these trades have been carefully prepared and are very interesting. The annual value of cotton hosiery is taken at 830,000*l.*, that of worsted, &c., is 870,000*l.* and of silk, 241,000*l.* In the manufacture of these goods it is estimated that 4,584,000 lbs. of raw cotton wool are used,—6,318,000 lbs. of English wool, and 140,000 lbs. of silk. The total number of persons deriving support from the manufacture is about 73,000, and about 1,050,000*l.* of floating capital is considered to be employed in the various branches of the trade.

The manufacture of straw plait is carried on chiefly at St. Alban's, Dunstable, Tring, and a few other places. That of boots and shoes is conducted on a very large scale at Northampton, from which place vast quantities of these articles are sent out ready for wear. Worcester, Dundee, and Woodstock are celebrated for their glove manufactures.

Gloves are of great antiquity in this island, as the word is evidently derived from the Anglo-Saxon "glof." They are not mentioned in Scripture, but were in use among the Romans in the time of Pliny the Younger. Xenophon states that their use among the Persians was considered a proof of their luxurious habits. Gloves have had many symbolical meanings. The gauntlet or glove thrown down was a mode of challenge, and still is practised as one of the forms of a royal coronation. Queen Elizabeth, it is well known, was very fond of gloves, of which numerous presents were made to her. White gloves are also presented to the judges on occasion of a maiden assize, the exact significance or origin of which practice has never been satisfactorily explained. Leather gloves are now made at Worcester, Yeovil, Woodstock, and London, and were formerly made at Leominster and Ludlow, but the trade in the latter places is quite decayed.

Plait straw is the straw of the wheat plant, selected especially from crops grown on dry chalky lands, such as those about Dunstable. The middle part of the straw above the last joint is selected; it is cut into lengths of eight or ten inches, and these are then split. The Leghorn or Tuscan is the straw of a variety of bearded wheat, grown expressly on poor sandy soils, pulled when green, and then bleached. Other kinds of the grass tribe besides wheat furnish straws available for plait-work.

PETROLEUM. See *НАФТНА*.

PE-TUNT-SE, is the Chinese name of the fusible earthy matter of their porcelain. It is analogous to our Cornish stone.

PEWTER, PEWTERER. (*Potier d'étain*, Fr.) Pewter is, generally speaking, an alloy of tin and lead, sometimes with a little antimony or copper, combined in several different proportions, according to the purposes which the metal is to serve. The English tradesmen distinguish three sorts, which they call plate, trifle, and ley pewter; the first and hardest being used for plates and dishes; the second for beer-pots; and the third for larger wine measures. The plate pewter has a bright silvery lustre when polished; the best is composed of 100 parts of tin, 8 parts of antimony, 2 parts of bismuth, and 2 of copper. The trifle is said by some to consist of 83 of tin, and 17 of antimony; but it generally contains a good deal of lead. The ley pewter is composed of 4 of tin, and 1 of lead. As the tendency of the covetous pewterer is always to put in as much of the cheap metal as is compatible with the appearance of his metal in the market, and as an excess of lead may cause it to act poisonously upon all vinegars and many wines, the French government long ago appointed Fourcroy, Vauquelin, and other chemists, to ascertain by experiment the proper proportions of a safe pewter alloy. These commissioners found that 18 parts of lead might, without danger of affecting wines, &c., be alloyed with 82 parts of tin; and the French government in consequence passed a law, requiring pewterers to use $8\frac{1}{2}$ of tin in 100 parts, with a tolerance of error amounting to $1\frac{1}{2}$ per cent. This ordonnance, allowing not more than 18 per cent. of lead at a maximum, has been extended to all vessels destined to contain alimentary substances. A table of specific gravities was also published, on purpose to test the quality of the alloy; the density of which, at the legal standard, is 7.764. Any excess of lead is immediately indicated by an increase in the specific gravity above that number.

The pewterer fashions almost all his articles by casting them in moulds of brass or bronze, which are made both inside and outside in various pieces, nicely fitted together, and locked in their position by ears and catches or pins of various kinds. The moulds must be moderately heated before the pewter is poured into them, and their surfaces should be brushed evenly over with pounce powder (sandarach) beaten up with white of egg. Sometimes a film of oil is preferred. The pieces, after being cast, are turned and polished; and if any part needs soldering, it must be done with a fusible alloy of tin, bismuth, and lead.

Britannia metal, the kind of pewter of which English teapots are made, is said to be an alloy of equal parts of brass, tin, antimony, and bismuth; but the proportions differ in different workshops, and much more tin is commonly introduced. Queen's metal is said to consist of 9 parts of tin, 1 of antimony, 1 of bismuth, and 1 of lead; it serves also for tea-pots and other domestic utensils.

A much safer and better alloy for these purposes may be compounded by adding to 100 parts of the French pewter, 5 parts of antimony, and 5 of brass to harden it. The English ley pewter contains often much more than 20 per cent. of lead. Under TIN, will be found the description of an easy method of analyzing its lead alloys.

PHANTASMAGORIA. The phantasmagoria lanterns are a scientific form of magic lantern, differing from it in no essential principle. The images they produce are variously exhibited, either on opaque or transparent screens. The light is an improved kind of solar lamp. The manner in which the beautiful melting pictures called dissolving views are produced, as respects the mechanism employed, deserves to be explained. The

arrangement adopted in the instrument is the following:—Two lanterns of the same size and power, and in all respects exactly agreeing, are arranged together upon a little tray or platform. They are held fast to this stand by screws, which admit of a certain degree of half-revolving motion from side to side, in order to adjust the foci. This being done in such a manner that the circle of light of each lantern falls precisely upon the same spot upon the screen, the screws are tightened to the utmost extent so as to remove all possibility of further movement. The dissolving apparatus consists of a circular tin plate japped in black, along three parts of the circumference of which a crescentic aperture runs, the interval between the horns of the crescent being occupied by a circular opening, covered by a screwed plate, removable at pleasure. This plate is fixed to a horizontal wooden axis, at the other end of which is a handle, by which the plate can be caused to rotate. The axis of wood is supported by two pillars connected with a flat piece which is secured to the tray. This apparatus is placed between the lanterns in such a manner that the circular plate is in front of the tubes of both, while the handle projects behind the lanterns at the back. The plate can, therefore, be turned round by means of the handle without difficulty, from behind. A peg of wood is fixed into the axis, so as to prevent its effecting more than half a revolution. The widest part of the crescentic opening in the plate is sufficient to admit all the rays of the lantern before which it happens to be placed. On the plate being slowly turned half round, by means of the handle behind, the opening narrows until it is altogether lost in one of the horns of the crescent. The light of that lantern is gradually cut off as the aperture diminishes, until it is at length wholly shaded under the moveable cover occupying the interval between the horns of this crescentic opening. In proportion as the light is cut off from one, it is let on from the other tube, in consequence of the gradually increasing size of the crescent revolving before it, until at length the widest part of this opening in the plate is presented before the tube of the second lantern, the first being, as we have seen, shaded. This movement being reversed, the light is cut off from the second lantern, and again let on from the first, and so on alternately. Thus while the screen always presents the same circle of light, yet it is derived first from one lantern, then from the next.

When in use a slider is introduced into each lantern. The lantern before the mouth of which the widest part of the opening in the plate is placed, exhibits the painting on the screen, the light of the other lantern being then hid behind the cover. On turning the handle, this picture gradually becomes shaded, while the light from the second lantern streams through the widening opening. The effect on the screen is the melting away of the first picture, and the brilliant development of the second, the screen being at no instant left unoccupied by a picture.

The principle involved in this apparently complex, but in reality simple mechanism, is, merely the obscuration of one picture, and the throwing of a second in the same place on the screen. And it may be accomplished in a great variety of ways. Thus by simply placing a flat piece of wood, somewhat like the letter Z on a point in the centre, so that alternately one or the other of the pieces at the end should be raised or depressed before the lanterns, a dissolving scene is produced. Or, by fixing a moveable upright shade, which can be pushed alternately before one or the other of the lanterns, the same effect is produced.

Individuals exist in this metropolis whose sole occupation consists in painting the minute scenes or slides used for the phantasmagoria lanterns. The perfection to which these paintings are brought is surprising. There are two methods by which the sliders now employed are produced. In one of these, the outline and detail are entirely the work of the artist's pencil. For pictures representing landscapes, or wherever a spirited painting is required, this is the exclusive method employed. The colours are rendered transparent by being ground in Canada balsam and mixed with varnish. The other method is a transfer process. The outlines of the subject are engraved on copper plates, and the impression is received from these on thin sheets of glue, and is then transferred to a plate of glass, the impression being burnt in the same manner as is effected in earthenware. Sliders produced in this way receive the distinctive name of copper plate sliders. The subject is merely represented in outline, it being left to the artist to fill up with the necessary tints, &c. The advantages of this method for the production of paintings of a limited kind are obvious. Latterly photography on glass has been employed to obtain pictures for the magic lantern.

PHARMACEUTICAL PRODUCTS.—*Hops.* These hops are samples of the varieties in most estimation for the purposes of the brewer. The Goldings take their name from that of a grower who first introduced them; they are considered to be the finest, richest and most valuable in the market, varying, however, according to the soil in which they are grown and the treatment they receive; Jones's are of shorter growth than the others, and are thus useful by enabling the grower to make use of the poles which would be too short for the Golding or other varieties. Colegates are hardy but backward at harvest, running much to vine and capable of growing in comparatively poor soils.

These qualities are, however, of advantage, as the inferior soils may thus be beneficially occupied by them, and their harvest takes place after the finer sorts are all in. The grape hop takes its name from its habit of growing in clusters like the grape. It is hardy, not so particular as to soil as the Goldings, and is generally very productive in yield.

Some conception of the quantity of hops annually produced in Great Britain, principally in Kent, Sussex, Worcester, and Hereford, may be obtained from the fact that in 1842 the duty (2*d.* per lb.), amounted to 260,978*l.*: the plant belongs to the same natural family as hemp, *Cannalinaceæ*. Its botanical name is *Humulus lupulus*.

Pharmaceutical Extracts.—Pharmaceutical extracts were for a considerable period the most fallacious of all medical preparations. The high temperature to which they were subjected in the manufacture destroyed the active principle sought to be concentrated. Of late they have been prepared in some instances, by evaporation in the cold, a current of air being driven over the surface of the liquid. They are also safely obtainable by using an apparatus similar to that employed in the sugar manufacture.

Kouso; a new remedial agent for the removal of tape worm. That it is destructive to that parasitic disease has been satisfactorily shown. The plant has been long known in the East, and actively employed in Abyssinia. Dr. Pereira has given an elaborate account of this plant, which is known by the name of *Brayera anthelmintica*, from its properties and the name of its discoverer, Dr. Brayer. Wittstein and Martin have given chemical analyses of the plant.

Superphosphate of iron; a new preparation of iron recently introduced by Dr. Routh, supposed to be the same salt contained in the blood. It is free from all ferruginous taste, and so well adapted for children: believed to be more speedy in its action than the other salts of iron in cases of nervous debility, where there is a large quantity of phosphates voided by the urine, probably because it supplies directly to the brain the phosphorus, on the undue diminution of which the nervous derangement depends. Syrup of superphosphate of iron, adapted for administering the remedy to children, and probably the best form for general use.

PHOSPHORIC ACID, is the acid formed by the vivid combustion of phosphorus. In the British portion of the Exhibition, there was one acid missing which existed in great abundance and perfection amongst the German chemical preparations. We allude to the glacial phosphoric acid, of which that displayed by the Royal Prussian chemical manufactory at Schönebeck can scarcely be too highly spoken of. From some unknown cause, this has not attracted the attention which it deserves in the arts and manufactures of this country. For many of the wants of the dyer, the calico printer, the enameller, and even in the purification of some oils and fat, the glacial phosphoric acid has much to recommend it over any of the common acids at present in use. Nor need its price prove an insuperable obstacle to its introduction as a practical agent. Finely ground bone-ash, digested with a due proportion of oxalic acid and water, readily yields a solution of phosphoric acid, which requires only to be evaporated in a proper vessel to furnish at once this useful article. Unlike sulphuric and other strong acids, it is not decomposed by organic matter; and might hence be employed with great advantage in the precipitation of carmine and other delicate vegetable colours, as well as for more general purposes. Some experiments have also shown that, combined with alumina and a little boracic acid, it is capable of producing a glaze for earthenware of extreme beauty and durability, in addition to its perfectly innocuous character and power of improving the colours imparted by most metallic oxides when applied to earthenware.

PHOSPHORUS. This interesting simple combustible, being an object of extensive consumption, and therefore of a considerable chemical manufacture, I shall describe the requisite manipulations for preparing it at some detail. Put 1 cwt. of finely ground bone-ash, such as is used by the assayers, into a stout tub, and let one person work it into a thin pap with twice its weight of water, and let him continue to stir it constantly with a wooden bar, while another person pours into it, in a uniform but very slender stream, 78 pounds of concentrated sulphuric acid.

The heat thus excited in the dilution of the acid, and in its reaction upon the calcareous base, is favourable to the decomposition of the bone phosphate. Should the resulting sulphate of lime become lumpy, it must be reduced into a uniform paste, by the addition of a little water from time to time. This mixture must be made out of doors, as under an open shed, on account of the carbonic acid and other offensive gases which are extricated. At the end of 24 hours, the pap may be thinned with water, and, if convenient, heated, with careful stirring, to complete the chemical change, in a square pan made of sheet lead, simply folded up at the sides. Whenever the paste has lost its granular character, it is ready for transfer into a series of tall casks, to be further diluted and settled, whereby the clear superphosphate of lime may be run off by a siphon from

the deposit of gypsum. More water must then be mixed with the precipitate, after subsidence of which the supernatant liquor is again to be drawn off. The skilful operator employs the weak acid from one cask to wash the deposit in another, and thereby saves fuel in evaporation.

The collected liquors being put into a leaden, or preferably a copper pan, of proper dimensions, are to be concentrated by steady ebullition, till the calcareous deposit becomes considerable; after the whole has been allowed to cool, the clear liquor is to be run off, the sediment removed, and thrown on a filter. The evaporation of the clear liquor is to be urged till it acquires the consistence of honey. Being now weighed, it should amount to 37 pounds. One fourth of its weight of charcoal in fine powder, that is, about 9 pounds, are then to be incorporated with it, and the mixture is to be evaporated to dryness in a cast-iron pot. A good deal of sulphurous acid is disengaged along with the steam at first, from the reaction of the sulphuric acid upon the charcoal, and afterwards some sulphuretted hydrogen. When the mixture has become perfectly dry, as shown by the redness of the bottom of the pot, it is to be allowed to cool, and packed tight into stoneware jars fitted with close covers, till it is to be subjected to distillation. For this purpose, earthen retorts of the best quality, and free from air-holes, must be taken, and evenly luted over their surface with a compost of fire-clay and horse-dung. When the coating is dry and sound, the retort is to be two-thirds filled with the powder, and placed upon proper supports in the laboratory of an air-furnace, having its fire placed not immediately beneath the retort, but to one side, after the plan of a reverberatory; whereby the flame may play uniformly round the retort, and the fuel may be supplied as it is wanted, without admitting cold air to endanger its cracking. The gallery furnace of the palatinate (under *MARCUAY*) will show how several retorts may be operated upon together, with one fire.

To the beak of the retort properly inclined, the one end of a bent copper tube is to be tightly luted, while the other end is plunged not more than one quarter of an inch beneath the surface of water contained in a small copper or tin trough placed beneath, close to the side of the furnace, or in a wide-mouthed bottle. It is of advantage to let the water be somewhat warm, in order to prevent the concretion of the phosphorus in the copper tube, and the consequent obstruction of the passage. Should the beak of the retort appear to get filled with solid phosphorus, a bent rod of iron may be heated and passed up the copper tube, without removing its end from the water. The heat of the furnace should be most slowly raised at first, but afterwards equally maintained in a state of bright ignition. After 3 or 4 hours of steady firing, carbonic acid and sulphurous acid gases are evolved in considerable abundance, provided the materials had not been well dried in the iron pot; then sulphuretted hydrogen makes its appearance, and next phosphuretted hydrogen, which last should continue during the whole of the distillation.

The firing should be regulated by the escape of this remarkable gas, which ought to be at the rate of about 2 bubbles per second. If the discharge comes to be interrupted, it is to be ascribed either to the temperature being too low, or to the retort getting cracked; and if upon raising the heat sufficiently no bubbles appear, it is a proof that the apparatus has become defective, and that it is needless to continue the operation. In fact, the great nicety in distilling phosphorus lies in the management of the fire, which must be incessantly watched, and fed by the successive introduction of fuel, consisting of coke with a mixture of dry wood and coal.

We may infer that the process approaches its conclusion by the increasing slowness with which gas is disengaged under a powerful heat; and when it ceases to come over, we may cease firing, taking care to prevent reflux of water into the retort, from condensation of its gaseous contents, by admitting air into it through a recurved glass tube or through the lute of the copper adoper.

The usual period of the operation upon the great scale is from 24 to 30 hours. Its theory is very obvious. The charcoal at an elevated temperature disoxygenates the phosphoric acid with the production of carbonic acid gas at first, and afterwards carbonic oxide gas, along with sulphuretted, carburetted, and phosphuretted hydrogen, from the reaction of the water present in the charcoal upon the other ingredients.

The phosphorus falls down in drops, like melted wax, and concretes at the bottom of the water in the receiver. It requires to be purified by squeezing in a shamoy leather bag, while immersed under the surface of warm water, contained in an earthen pan. Each bag must be firmly tied into a ball form, of the size of the fist, and compressed, under the water heated to 190°, by a pair of flat wooden pincers, like those with which oranges are squeezed.

The purified phosphorus is moulded for sale into little cylinders, by melting it at the bottom of a deep jar filled with water, then plunging the wider end of a slightly tapering but straight glass tube into the water, sucking this up to the top of the glass, so as to

warm it, next immersing the end in the liquid phosphorus, and sucking it up to any desired height.

The tube being now shut at bottom by the application of the point of the left index, may be taken from the mouth and transferred into a pan of cold water to congeal the phosphorus; which then will commonly fall out of itself, if the tube be nicely tapered, or may at any rate be pushed out with a stiff wire. Were the glass tube not duly warmed before sucking up the phosphorus, this would be apt to congeal at the sides before the middle be filled, and thus form hollow cylinders, very troublesome and even dangerous to the makers of phosphoric match-bottles. The moulded sticks of phosphorus are finally to be cut with scissors under water to the requisite lengths, and put up in phials of a proper size; which should be filled up with water, closed with ground stoppers, and kept in a dark place. For carriage to a distance, each phial should be wrapped in paper, and fitted into a tin-plate case.

Phosphorus has a pale yellow colour, is nearly transparent, brittle when cold, soft and pliable, like wax, at the temperature of 70° F., crystallizing in rhombo-dodecahedrons out of its combination with sulphur, and of specific gravity 1.77. It exhales white fumes in the air, which have a garlic smell, appear luminous in the dark, and spontaneously condense into liquid phosphorous acid. Phosphorus melts in close vessels, at 95° F., into an oily-looking colourless fluid, begins to evaporate at 217.5°, boils at 554°, and if poured in the liquid state into ice-cold water, it becomes black, but resumes its former colour when again melted and slowly cooled. It has an acrid disagreeable taste, and acts deleteriously in the stomach, though it has been administered as a medicine by some of the poison-doctors of the present day. It takes fire in the open air at the temperature of 165°, but at a lower degree if partially oxidized, and burns with great vehemence and splendour.

Inflammable match-boxes (*briquets phosphoriques*) are usually prepared by putting into a small phial of glass or lead a bit of phosphorus, and oxidizing it slightly by stirring it round with a red-hot iron wire. The phial should be unstopped only at the instant of plunging into it the tip of the sulphur match which we wish to kindle. Bendix has given the following recipe for charging such match-phials. Take one part of fine dry cork rasping, one part of yellow wax, eight parts of petroleum, and four of phosphorus, incorporate them by fusion, and when the mixture has congealed by cooling, it is capable of kindling a sulphur match dipped into it. Phosphorus dissolves in fat oils, forming a solution luminous in the dark at ordinary temperatures. A phial half filled with this oil, being shaken and suddenly uncorked, will give light enough to see the dial of a watch by night.

There are five combinations of phosphorus and oxygen:—1. the white oxide; 2. the red oxide; 3. hypophosphorous acid; 4. phosphorous acid; 5. phosphoric acid. The last is the only one of interest in the arts. It may be obtained from the syrupy superphosphate of lime above described, by diluting it with water, saturating with carbonate of ammonia; evaporating, crystallizing, and gently igniting the salt in a retort. The ammonia is volatilized, and may be condensed into water by a Woulfe's apparatus while the phosphoric acid remains in the bottom of the retort. Phosphoric acid may be more readily produced by burning successive bits of phosphorus in a silver saucer, under a great bell jar inverted upon a glass plate, so as to admit a little air to carry on the combustion. The acid is obtained in a fine white snowy deposit; consisting, in this its dry state, of 44 of phosphorus and 56 of oxygen. That obtained from the syrupy solution is a hydrate, and contains 9.44 per cent. of water. If the atom of phosphorus be called 32 upon the hydrogen radix, then 5 atoms of oxygen = 40 will be associated with it in the dry acid = 72; and an additional atom of water = 9, in the hydrate, will make its prime equivalent 81. Phosphorous acid seems to contain no more than 3 atoms of oxygen.

The only salts of this acid much in demand are the phosphate of soda, and the ammonia-phosphate of soda. The former is prepared by slightly supersaturating superphosphate of lime with crystals of carbonate of soda; warming the solution, filtering, evaporating, and crystallizing. It is an excellent purgative, and not unpalatable. The triple phosphate is used in decimastic operations; and is described under METALLURGY.

PHOSPHORUS AMORPHOUS. Amorphous phosphorus was discovered by Dr. Schrötter, of Vienna. It is identical in composition with ordinary phosphorus, and may be reconverted into it without loss of weight, and that merely by a change of temperature. This substance remains unaltered in the atmosphere, is insoluble in sulphuret of carbon, in alcohol, ether, and naphtha. It requires a heat of 260° C. to restore it to the crystalline state, and it is only at that heat that it begins to take fire in the open air. It is not luminous in the dark at any ordinary temperature. The apparatus for making it consists of a double iron pan; the intermediate space between the two contains a metallic bath of an alloy of tin and lead; with a cast-iron cover to the inner vessel, fitted to the top end by means of a screw, and fastened to the outer vessel by screw pins. In the

interior iron vessel, a glass vessel is fitted, in which the phosphorus to be operated upon is placed. From this inner vessel a tube passes, and is dipped into water to serve as a safety valve. A spirit lamp is applied under that pipe if necessary, to prevent it being clogged with phosphorus. The phosphorus to be converted is first of all melted and then cooled under water, and dried as much as possible. A fire is now made under the other vessel, and the temperature raised to such a degree as to drive off the air, &c. The temperature is to be gradually raised, until bubbles escape at the end of the pipe, which take fire as they enter the air, and the heat may soon rise in the bath till it be 500° Fahr. This temperature must be maintained for a certain time to be determined by experience: the apparatus may then be allowed to cool. The converted phosphorus is difficult to detach from the glass. It is to be levigated under water, and then drained in a bag. The phosphorus when moist should be spread thinly on separate shallow trays of sheet iron or lead, so placed alongside each other as to receive the heat of steam, and lastly of chloride of calcium or of sand, till the phosphorus having been frequently stirred, shows no more luminous vapour. The operator should have water at hand to quench any fire that might arise. It is then to be washed till the water shows no trace of acid. Should the resulting phosphorus contain some of the unconverted article, this may be removed by bisulphuret of carbon. Thus, heat alone effects the transmutation.

Phosphorus and its Matches. Professor Schrötter's discovery of amorphous phosphorus has not hitherto led to any practical application towards diminishing the noxiousness of the manufacture of lucifer matches; though this curious substance may now be had at a moderate price from Messrs. Sturge of Birmingham. At Dixon's manufactory, Newton Heath, near Manchester, piles of timber are stored up ready for use; it is rapidly reduced into blocks of proper length, and next into tiny sticks, by machinery. These are tied up in bundles of about 8 inches in diameter, and carried into the sulphuring room, where they are dipped in the melted brimstone contained in an iron pot resting over a moderate fire. Each bundle is turned round and pressed, to prevent the cohesion of the sticks composing it.

They are now transferred to the phosphorus apartment, where they are dipped into a composition of chlorate of potash, phosphorus and glue, spread in a thin layer on a slab of stone or marble heated beneath by steam or hot water. The bundles are for this purpose arranged in frames about 2 feet long and 1 broad; but not in contact with each other. The operator holds the frame lengthwise, and dips the ends of the matches in the composition, taking care that all of them are coated. They are now sorted in a separate room, and put into boxes. Each box of lucifer matches, price retail one half-penny, passes through the hands of 17 persons, chiefly children, who earn by piece-work from 3s. to 5s. per week; while the adults earn from 9s. to 12s.

The peculiar and most remarkable disease to which the workers in such a factory are subject is described in the Dublin Quarterly Journal of Science for August, 1851, by Mr. Harrison.

The first symptom is toothache, while the jaw is getting into a carious state, and the disease silently creeps on, until the sufferer becomes a loathsome object, or dies, becoming unable to open his jaws, of which the bones are being necrosed. Dreadful mutilations ensue, from the necessary surgical operations; causing the loss of the greater portion of the lower jaw. There are at this time in the factory several persons who have suffered severely. In the Museum of the Manchester Infirmary is the lower jaw of a young woman who is now at work. In some cases the bone in its diseased state has a spongy cellular appearance, with excrescences of a similar character adhering to it. The teeth generally continue sound and white, while the jaw that contains them is altered in texture and apparently dead. Loss of the greater part or whole of the lower jaw, is a frequent result. The cause, and cure, or prevention of this horrible new disease are still to be discovered.

Phosphorus paste for the destruction of rats and mice. The Prussian government issued an ordonnance on the 27th April, 1843, directing the following composition to be substituted for arsenic, for destroying rats and mice; enjoining the authorities of the different provinces to communicate, at the expiration of a year, the results of the trials made with it, with the view of framing a law on this subject.

The following is the formula for this paste:—

Take of phosphorus 8 parts, liquefy it in 180 parts of lukewarm water, pour the whole into a mortar, add immediately 180 parts of rye meal; when cold mix in 180 parts of butter melted, and 125 parts of sugar.

If the phosphorus is in a finely divided state, the ingredients may be all mixed at once, without melting them.

This mixture will retain its efficacy for many years, for the phosphorus is preserved by the butter, and only becomes oxidized on the surface.

Rats and mice eat this mixture with avidity; after which they swell out and soon die.

M. Simon has employed this mixture for many years, with constant success, by placing it in places frequented by these animals. According to him, the phosphorus is less dangerous than arsenic, for supposing the mixture to be badly made, and the phosphorus imperfectly divided, the oxidation which would take place in a few days would render it nearly inactive; and it would be almost impossible to employ it for the intentional poisoning of human beings.

PHOTOGRAPHY is the art of making pictorial impressions of objects by the action of light upon paper, &c., prepared with certain substances, and exposed to the sun or in the focus of a camera obscura to the image of the object to be represented; which impressions are then fixed by other chemical reagents. Photographic paper may be made by dipping Whatman's glazed post paper into brine containing 90 grains of common salt dissolved in an ounce of water, wiping it with a towel, brushing over one side of it with a broad camel-hair brush, a solution of nitrate of silver, containing 50 grains to the ounce of distilled water, and drying it in the dark. The paper may be rendered more sensitive by repeating the above operation; drying it between each step. It affords perfect images of leaves and petals laid upon it, and exposed simply to the sunbeams. A solution of 100 grains of bromide of potassium in an ounce of distilled water answers still better than brine. The paper, when dry, is to be brushed over on one side with a solution containing 100 grains of nitrate of silver to an ounce of water; the paper being brushed and dried in the dark. If the application of the nitrate of silver be repeated, it will render the paper more sensitive. The silvered side should be marked. This paper laid flat under painted glass, as also lace, leaves, feathers, ferns, &c., and exposed to the light of day, takes the impression of the objects. It is to be then washed with lukewarm water, and finally dipped in a solution containing one ounce of hyposulphite of soda, in about a pint of distilled water. The design of the object is necessarily reversed; the light parts forming the dark shades of the photogenic impression, and the dark parts the lighter ones. But a direct picture may be obtained by applying that paper, rendered transparent with white wax (see CALOTYPÉ), upon a sheet of white photogenic paper, and exposing it to the sunbeams, or bright daylight.

A modification of photography, called Chrysotype by its inventor, Sir John Herschel, consists in washing the paper in a solution of ammonia-citrate of iron, drying it, and brushing it over with a solution of ferro-sesquicyanure of potassium. This paper, when dried in a perfectly dark room, is ready for use, the image being finally brought out by a neutral solution of silver.

Another modification by Sir John, called Cyanotype, is as follows:—Brush the paper with the solution of the ammonia-citrate of iron, so strong as to resemble sherry wine in colour; expose the paper in the usual way, and pass over it very sparingly and evenly a wash made by dissolving common ferro-cyanide of potassium. As soon as this liquid is applied, the negative picture vanishes, and is replaced by the positive one, of a violet blue colour, on a greenish yellow ground, which at a certain time possesses a high degree of sharpness, and singular beauty of tint.

The improved process of photography, recently contrived by Mr. Robert Hunt, is performed by washing over good letter paper with the following liquid:—

| | | | | | |
|---------------------------------------|---|---|---|----------------|-------|
| A saturated solution of succinic acid | - | - | - | 2 | drams |
| Mucilage of gum arabic | - | - | - | $\frac{1}{2}$ | do. |
| Water | - | - | - | $1\frac{1}{2}$ | do. |

When the paper is dry, it is washed over once with a solution containing 1 drachm of nitrate of silver in 1 ounce of distilled water. The paper is allowed to dry in the dark, and it is fit for use. It can be preserved in a portfolio, and employed at any time in the camera obscura, exposing it to the light from two to eight minutes according to its vivacity. When the paper is taken out of the camera, no trace of a picture can be seen. To produce this effect, mix 1 dram of a saturated solution of sulphate of iron, with 2 or 3 drams of mucilage of gum arabic, and brush over the paper evenly with this mixture. In a few seconds the latent images are seen to develop themselves, producing a negative photographic picture. The excess of the iron solution is to be washed off with a sponge whenever the best effect appears. The drawing is then to be soaked a short time in water, and is fixed by washing over with ammonia, or preferably with hyposulphite of soda; taking care to wash out the excess of salt. From the pictures thus produced, any number of others, corrected in light and shadow, may be produced by using like succinated papers, in the common way of transfer in sunshine. See also CALOTYPÉ, DAQUERREOTYPÉ and HELIOGRAPHY.

William Henry Fox Talbot, Esq., Laycock Abbey, Chippenham, has obtained a patent for improvements in photography. Patent dated June 12th, 1851.

The first part of this invention consists in obtaining photographic images on plates of glass prepared by the following means:—A plate of glass should be selected having

a smooth and well-polished surface; and in order to obtain a photographic picture, the operator proceeds as follows:

1. Takes albumen or white of egg, and mixes the most liquid portions thereof (rejecting the rest) with an equal quantity of water, and having spread the mixture smoothly and evenly over the surface of the glass, allows it to dry spontaneously, or dries it at a fire.

2. He mixes an aqueous solution of nitrate of silver with a large proportion of alcohol, so that the mixture shall contain about 9 grains of the nitrate to each ounce of liquid. (This proportion may be varied from 1 to 6 grains in the ounce of liquid; but 9 grains is considered to be the best proportion.)

3. He dips the prepared plate for a few seconds into this mixture, then withdraws and dries it by a gentle heat, or allows it to dry spontaneously.

4. He dips the plate into distilled water, to remove any superfluous nitrate of silver.

5. He applies a second coating of albumen, in the same way as above directed, and dries the plate by the application of gentle heat, avoiding the use of too much heat, by which the nitrate of silver might be decomposed.

6. He takes an aqueous solution of protiodide of iron, containing 140 grains of protiodide to the ounce of water. A small quantity of free iodine in the solution, by which its colour would be rendered slightly yellow, will be found to be of advantage. To one measure of the solution, he adds one of acetic acid and ten of alcohol, and allows the mixture to stand for a few days previous to use.

7. He dips the plate into the solution, or allows the liquid to pass over the whole of its surface in a continuous stream. It is then dried, when it should be of a pale yellow colour, very clear, and uniformly transparent; and this completes the preparation of the plates. All the preceding operations may be performed in moderate daylight, but avoiding exposure to too strong a light, or to sunshine.

8. When it is desired to obtain a photographic picture, the operator takes a solution of nitrate of silver containing 100 grains of nitrate of silver to an ounce of water, and, having mixed two measures of the same with two of acetic acid and one of water, he dips the albumenized plate therein once or twice, for a few seconds each time (performing the operation in a darkened room or by candlelight), for the purpose of rendering it sensitive. If the weather is cold, the plate should be slightly warmed before so dipping it. He then removes it to the camera without loss of time, as the plate ought to be used a few minutes after taking it out of the solution; and when a sufficiently strong photographic image is supposed to be obtained, the plate is transferred from the camera to the dark chamber or operating room.

9. It is then immersed in a solution of sulphate of iron, composed by mixing one measure of a saturated solution thereof in water with two measures of water (but the solution may be stronger or weaker, at the discretion of the operator,); by which the previously invisible images will be rapidly rendered perceptible.

10. The plate is then washed, and dipped in a rather strong solution of hyposulphite of soda in water, which, generally, in about a minute renders every part of the image more distinct and visible. The picture is then washed in distilled water, and the surface of the plate may be cleansed from any particles of dust, or other impurities, by rubbing it gently with cotton dipped in water; and if the above-described operations have been properly performed, the surface of the plate will not be at all injured by this cleaning. The picture is then dried, and the operation is finished. For the purpose of better preserving the picture, the plate may be covered with a coating of albumen or fine transparent varnish.

Although throughout the above processes certain proportions of chemical substances have been named, they may be varied very considerably, as is also the case in photographic operations generally.

The images obtained by his improved method, Mr. Talbot calls "Amphitypes," because they appear either positive or negative, according to the circumstances of light under which they are viewed. Thus, if held against a bright light, or against a sheet of white paper, they appear negative, and the reverse when held against a black surface and seen in obliquely reflected light. It is in the power of the operator, by varying the proportions of the chemicals employed, to obtain at pleasure positive images more or less distinct in comparison with the negative images; when it is intended to copy the image upon paper, it is desirable to obtain as strong a negative as possible on the glass plate, which is then copied on the paper, to produce thereon a positive image in the usual manner: but when the operator wishes to have a picture on the glass, he should endeavour to obtain a strong positive image. When this is obtained to his satisfaction, it may be preserved from injury and from contact with the air, by pouring black paint over the pictured side of the plate, and then by turning the glass the picture will be seen correctly, and not reversed as regards the right and left sides. This method of blacking one side of the plate is not, however, any part of the present invention. Throughout the

specification the words negative and positive are made use of in the senses in which they are generally employed by photographers, viz., a positive image is that in which the lights and shades of the object are represented by lights and shades in the photograph, and a negative image is that in which a reverse effect is produced.

The method of operating just described is that which Mr. Talbot recommends when the object is close at hand, and the operator is in the vicinity of a darkened room, to which he can retire for the purpose of rendering his plates sensitive; but under circumstances where the object is at a distance, and when the operator is on a journey or otherwise removed from any house or place where such conveniences exist, the following method of procedure may be adopted:—The operator constructs a glass cell with equal and parallel sides, open at the top and closed at the bottom and sides, and quite watertight, of a size just sufficient to receive one of the photographic plates, but not much greater, in order that there may be no waste of the chemicals employed. The posterior glass of the cell has one of its sides ground or unpolished, and the cell, when in use, is placed at the hinder part of the camera, so that when directed towards an object, the unpolished or ground surface may answer the purpose of the sheet of ground glass introduced in cameras to place the objects in their true focus. Allowance must, of course, be made for the unusual position occupied by the ground glass in this case. The top of the cell is provided at one corner with a funnel for the introduction of liquid, and the bottom is furnished with a stopcock and waste pipe terminating in a caoutchouc tube, which may be moved by hand from one to the other of two vessels which are provided to receive the used liquors escaping from the camera: the nitrate of silver solution is too expensive to be wasted, but the other ingredients, when once used, may be thrown away. These preparations made, the operator pours into the cell a quantity of liquid sufficient to fill it nearly full when it contains one of the photographic plates, and notes the quantity required. He then provides four bottles of that capacity, one of which he fills with solution of nitrate of silver, prepared as before directed under operation 8.; the second bottle is to contain a solution of sulphate of iron, as directed under operation 9.; the third bottle is filled with water, and the fourth with a strong solution of hyposulphite of soda. These quantities are sufficient for obtaining a single photographic picture, and when they are used, the bottles must be filled again. Having prepared a number of glass plates by means of the processes before described, up to No. 7. inclusive, they are to be packed in a box ready for use: the operator, when he desires to obtain a photographic picture of an object, takes one of the plates from the box (which he can do without injury to it, as the plates in this condition are not sensitive to light), and place it in the camera, the focus of which he adjusts to the object. He then closes the front lens or object glass, lowers a curtain over the camera box, leaving exposed only the funnel at the top (and care should be taken to guard against any light entering through this), and the waste pipe at the bottom of the cell, and pours into the cell, through the funnel, the contents of the first bottle (nitrate of silver solution), for the purpose of rendering the plate sensitive to light. He may then proceed in two different ways. That is, he may open the front lens, and obtain the image while the plate is immersed in the solution; or, before opening the front lens, he may allow the nitrate of silver solution to escape through the waste pipe, and he will then obtain an image on the plate while the liquid is adhering to its sides. In the latter case, or after allowing the solution to escape, if the former method is adopted, he closes the stopcock, and successively pours into the cell the contents of the second and third bottles, allowing each to remain in for about half a minute; and, finally, he pours in the hyposulphite of soda solution, after which the plate is removed, and the image being now fixed, and not liable to injury from exposure to air, the plate is washed and placed in a box to be finished and varnished when the day's operations are completed. Another method, but one which is less simple, is to use four bottles of larger size than those above described, but containing the same liquids. These bottles are placed on a stand above the camera, and from each of them descends a tube of India rubber furnished with two stopcocks, which are placed at such distances apart, that the interval of tube between them shall be of a capacity equal to that of the cell when it contains a plate. These tubes dip into a funnel which communicates by a suitable pipe with the funnel leading to the cell. The liquids are successively supplied to the cell from the bottles, and the method of operating according to this system is the same as that just described. The images obtained on glass by these means may be copied on to paper, in the usual manner. In fixing the images on paper, it is recommended, after washing them, to immerse the paper in a hot solution of iodide of potassium before dipping in the solution of hyposulphite of soda; by which means a better fixation of the image will be obtained.

Under this branch of his invention, Mr. Talbot claims the mode of preparing the glass plates, especially the use of a weak solution of nitrate of silver, immediately after the first coating of albumen; also the conjoint use of protiodide of iron and sulphate of iron, upon albumenized glass plates; and also the simultaneous production upon glass plates

of images which are both positive and negative, according to the light in which they are viewed. (In the specification of a patent granted to Messrs. Malone and Talbot, 19th Dec. 1849, a method is described of producing such images, which differs from the present in the prior formation of the negative image, which is afterwards converted into a positive one.) Also the apparatus described to be used along with the camera enabling the operator to work without the necessity of darkening the apartment in which he works, or of employing a tent or other contrivance for working in the shade, when taking photographic pictures at a distance from any house. The form of the apparatus may be considerably varied, but the essential point is, that the glass plate is placed in the cell in a partly prepared state, in which it is insensible to light, and is not removed from the cell, until the photographic picture is finished, with the exception of the final washing and drying. The patentee does not claim as new the mere use of a glass cell containing nitrate of silver, into which the photographic plate is dropped previous to, or during the formation of the image; but he claims the addition of the stopcock and waste-pipe, and the general arrangements, which render unnecessary the removal of the plate from the cell before the picture is finished. He states, also, that he believes the arrangement of four vessels furnished with tubes and stopcocks for pouring measured quantities of different fluids into the glass cell to be a new one.

The second part of the invention consists of a method of obtaining, under certain circumstances, the photographic picture of objects which are in rapid motion. An electric battery of the greatest power which can be conveniently obtained, is arranged in a darkened room, and, supposing the moving body whose picture is required is a wheel revolving upon its axis, the camera is placed at a convenient distance from it, and adjusted so as to have the image of the object in its focus. A glass plate is then taken, which has been previously prepared, in the way described above, and it is rendered sensitive with nitrate of silver in the way also above described: it is then placed in the camera and the electric battery is discharged, producing a sudden flash of light, which illuminates the object; the image thus taken on the glass plate is then rendered visible, and the process finished, as before directed. If the process is properly conducted, a distinct positive image of the moving body will be seen upon the glass, the rapidity of the motion not affecting the accuracy of the delineation.

What is claimed under this head of the invention is the use of the instantaneous light of an electric battery in such a way as to obtain the photographic image of a body illuminated thereby.

PICAMARE, is a thick oil, one of the six new principles detected by M. Reichenbach in wood-tar. See CREOSOTE and PARAFFINE. Picamare constitutes 1-6th of beech-tar.

PICKLES are various kinds of vegetables and fruits preserved in vinegar. The substances are first well cleaned with water, then steeped for some time in brine, and afterwards transferred to bottles, which are filled up with good vinegar. Certain fruits, like walnuts, require to be pickled with scalding hot vinegar; others, as red cabbage, with cold vinegar; but onions, to preserve their whiteness, with distilled vinegar. Wood vinegar is never used by the principal pickle manufacturers, but the best malt or white wine vinegar, No. 22 or 24. Kitchener says, that by parboiling the pickles in brine, they will be ready in half the time of what they require when done cold. Cabbage, however, cauliflowers, and such articles, would thereby become flabby, and lose that crispness which many people relish. When removed from the brine they should be cooled, drained, and even dried before being put into the vinegar. To assist the preservation of pickles, a portion of salt is often added, and likewise to give flavour, various spices, such as long pepper, black pepper, white pepper, allspice, ginger, cloves, mace, garlic, mustard, horseradish, shallots, capsicum. When the spices are bruised, they are most efficacious, but they are apt to render the pickle turbid and discoloured. The flavouring ingredients of Indian pickle are curry powder mixed with a large proportion of mustard and garlic. Green peaches are said to make the best imitation of the Indian mango.

I have examined the apparatus in the great fish-sauce, pickle, and preserved fruit establishment of Messrs. Crosse and Blackwell, Soho Square, and found it arranged on the principles most conducive to economy, cleanliness, and salubrity; no material employed there is ever allowed to come into contact with copper. A powerful steam boiler is placed in one corner of the ground floor of the factory, from which a steam pipe issues, and is laid horizontally along the wall about 4 feet above the floor. Under this pipe a range of casks is placed, into the side of each of which a branch steam-pipe, furnished with a stopcock, is inserted, while the mouth of the cask is exactly closed with a pan of salt-glazed earthenware, capable of resisting the action of every acid, and incapable of communicating any taint to its contents. These casks form, by their non-conducting quality as to heat, the best kind of steam-jackets. In these pans the vinegars with their compounds are heated, and the fish and other sauces are pre-

pared. The waste steam at the farthest extremity of the pipe is conducted into a reservoir of clean water, so as to furnish a constant supply of hot water for washing bottles and utensils.

The confectionery and ham smoking compartments are placed in a separate fire-proof chamber on the same floor.

The floor above is occupied along the sides with a range of large rectangular cast-iron cisterns, furnished with a series of steam-pipes, laid gridiron-wise along their bottoms, which pipes are covered with a perforated wooden shelf. These cisterns being filled up to a certain height above the shelf with water, the bottles full of green goose-berries, aprilots, cherries, &c., to be preserved, are set upon the shelf, and the steam being then admitted into the gridiron pipes, the superjacent water gets gradually heated to the boiling point; the air in the bottles round the fruit is thus partly expelled by expansion, and partly disoxygenated by absorption of the green vegetable matter. In this state the bottles are tightly corked, and being subsequently sealed, preserve the fruit fresh for a very long period.

The sauces, pastes, and potted meats prepared in the above described apparatus, can seldom be rivalled, and probably not surpassed, in the kitchens of the most fastidious gastronomes.

PICROMEL, is the name given by M. Thenard to a black bitter principle which he supposed to be peculiar to the bile. MM. Gmelin and Tiedemann have since called its identity in question.

PICROTOXINE, is an intensely bitter poisonous vegetable principle, extracted from the seeds of the *Menispermum cocculus*, (*Cocculus Indicus*). It crystallizes in small white needles, or columns, dissolves in water and alcohol. It does not combine with acids, but with some bases, and is not therefore of an alkaline nature, as had been at first supposed.

PIGMENTS, VITRIFIABLE, belong to five different styles of work: 1. to enamel painting; 2. to painting on metals; 3. to painting on stoneware; 4. to painting on porcelain; 5. to stained glass. See **VITRIFIABLE PIGMENTS**.

PIGMENTS. 1. *White*. Alumina, white clay, heavy spar, chalk, gypsum, alabaster, and starch, and sulphate of lead.

2. *Blues*. Lapis lazuli blue; azure blue; artificial ultramarine; Thenard's blue or cobaltic; Giessen blue is Prussian blue dissolved in oxalic acid.

Copper blue, or hydrated oxide of copper, called mountain blue; indigo; litmus blue; blue (violet) from logwood by salt of tin and alkalis.

3. *Greens*. Bremer; hydrated oxide of copper by decomposing a salt of copper with alkali; Brunswick and mountain green are arsenites of copper, acetate of copper or verdigris; Scheele's green; mixtures of chrome yellow and Prussian blue; oxide of chrome as an enamel colour; green earth, silicate and phosphate of the protoxide of iron; vegetable green, an extract of buckthorn berries, called also sap-green.

4. *Yellow*. Chrome; yellow antimonite of lead or Naples yellow, orpiment; hydrated oxide of iron; yellow ochre or Sienna yellow; gamboge; turmeric; yellow wood or fustic; quercitron; weld; yellow berries; saffron; annatto.

Red pigments. Cinnabar; basic chromate of lead; red lead; oxide of iron; red lake dyes; carmine; cochineal; kermes; Brazil wood; madder and its lake; lac lake; alkanet root; sandal wood; safflower; umber, or earthy clay ironstone; Cologne umber; earthy brown coal, lamp black, and Frankfort vine black; bone black; sepia, obtained by drying the black fluid of the cuttle-fish, extracted by means of caustic lye; catechu; dyes with mordants.

PIMENTO, *Myrtus pimenta*, or Jamaica pepper, consists, according to Bonastre's complicated analysis, of:—

| | Shells or Capsules. | Kernels. |
|--|---------------------|----------|
| Volatile oil - - - - - | 10·0 | 5·0 |
| Soft green resin - - - - - | 8·0 | 2·5 |
| Fatty concrete oil - - - - - | 0·9 | 1·2 |
| Extract containing tannin - - - - - | 11·4 | 39·8 |
| Gum - - - - - | 3·0 | 7·2 |
| Brown matter dissolved in potash - - - - - | 4·0 | 8·0 |
| Resinoid matter - - - - - | 1·2 | 3·2 |
| Extract containing sugar - - - - - | 3·0 | 8·0 |
| Gallic and malic acids - - - - - | 0·6 | 1·6 |
| Vegetable fibre - - - - - | 50·0 | 16·0 |
| Ashes charged with salts - - - - - | 2·8 | 1·9 |
| Moisture and loss - - - - - | 4·1 | 4·8 |

| | Imported. | Retained for Consumption. | Exported. | Duty Received. |
|------|--------------|---------------------------|--------------|----------------|
| | <i>cwts.</i> | <i>cwts.</i> | <i>cwts.</i> | £ |
| 1850 | 20,448 | 3,564 | 8,510 | 936 |
| 1851 | 14,840 | 8,935 | 17,353 | 1038 |

PINCHBECK, is a modification of brass; see that article and COPPER.

PINE-APPLE YARN and CLOTH. In Mr. Zincke's process, patented in December, 1836, for preparing the filaments of this plant, the *Bromelia ananias*, the leaves being plucked, and deprived of the prickles round their edges by a cutting instrument, are then beaten upon a wooden block with a wooden mallet, till a silky-looking mass of fibres be obtained, which are to be freed by washing from the green fecula. The fibrous part must next be laid straight, and passed between wooden rollers. The leaves should be gathered between the time of their full maturity and the ripening of the fruit. If earlier or later, the fibres will not be so flexible, and will need to be cleared by a boil in soapy water for some hours, after being laid straight under the pressure of a wooden grating, to prevent their becoming entangled. When well washed and dried, with occasional shaking out, they will now appear of a silky fineness. They may be then spun into porous rovings, in which state they are most conveniently bleached by the ordinary methods.

Specimens of cambric, both bleached and unbleached, woven with these fibres, have been recently exhibited, which excited hopes of their rivaling the finest flax fabrics, but in my opinion without good reason, on account of their want of strength.

PINEY TALLOW, is a concrete fat obtained by boiling with water the fruit of the *Fateria indica*, a tree common upon the Malabar coast. It seems to be a substance intermediate between tallow and wax; partaking of the nature of stearine. It melts at $97\frac{1}{2}^{\circ}$ F., is white or yellowish, has a spec. grav. of 0.926; is saponified by alkalis, and forms excellent candles. Dr. Benjamin Babington, to whom we are indebted for all our knowledge of piney tallow, found its ultimate constituents to be, 77 of carbon, 12.3 of hydrogen, and 10.7 of oxygen.

PIN MANUFACTURE. (*Fabrique d'épingles*, Fr.; *Nadelfabrik*, Germ.) A pin is a small bit of wire, commonly brass, with a point at one end, and a spherical head at the other. In making this little article, there are no less than fourteen distinct operations.

1. *Straightening the wire.* The wire, as obtained from the drawing-frame, is wound about a bobbin or barrel, about 6 inches diameter, which gives it a curvature that must be removed. The straightening engine is formed by fixing 6 or 7 nails upright in a waving line on a board, so that the void space measured in a straight line between the first three nails may have exactly the thickness of the wire to be trimmed; and that the other nails may make the wire take a certain curve line, which must vary with its thickness. The workman pulls the wire with pincers through among these nails, to the length of about 30 feet, at a running draught; and after he cuts that off, he returns for as much more; he can thus finish 600 fathoms in the hour. He next cuts these long pieces into lengths of 3 or 4 pins. A day's work of one man amounts to 18 or 20 thousand dozen of pin-lengths.

2. *Pointing*, is executed on two iron or steel grindstones, by two workmen, one of whom roughens down, and the other finishes. Thirty or forty of the pin wires are applied to the grindstone at once, arranged in one plane, between the two forefingers and thumbs of both hands, which dexterously give them a rotatory movement.

3. *Cutting these wires into pin-lengths.* This is done by an adjusted chisel. The intermediate portions are handed over to the pointer.

4. *Twisting of the wire for the pin-heads.* These are made of a much finer wire, coiled into a compact spiral, round a wire of the size of the pins, by means of a small lathe constructed for the purpose.

5. *Cutting the heads.* Two turns are dexterously cut off for each head, by a regulated chisel. A skilful workman may turn off 12,000 in the hour.

6. *Annealing the heads.* They are put into an iron ladle, made redhot over an open fire, and then thrown into cold water.

7. *Stamping or shaping the heads.* This is done by the blow of a small ram, raised by means of a pedal lever and a cord. The pin-heads are also fixed on by the same operative, who makes about 1500 pins in the hour, or from 12,000 to 15,000 per diem, exclusive of one-thirteenth, which is always deducted for waste in this department, as well as in the rest of the manufacture. Cast heads, of an alloy of tin and antimony, were introduced by patent, but never came into general use.

8. *Yellowing or cleansing the pins*, is effected by boiling them for half an hour: in sour beer, wine lees, or solution of tartar; after which they are washed.

9. *Whitening or tinning.* A stratum of about 6 pounds of pins is laid in a copper pan, then a stratum of about 7 to 8 pounds of grain tin; and so alternately till the vessel be filled; a pipe being left inserted at one side, to permit the introduction of water slowly at the bottom, without deranging the contents. When the pipe is withdrawn, its space is filled up with grain tin. The vessel being now set on the fire, and the water becoming hot, its surface is sprinkled with 4 ounces of cream of tartar; after which it is allowed to boil for an hour. The pins and tin grains are, lastly, separated by a kind of a cullender.

10. *Washing the pins,* in pure water.

11. *Drying and polishing them,* in a leather sack filled with coarse bran, which is agitated to and fro by two men.

12. *Winnowing,* by fanners.

13. *Pricking the papers* for receiving the pins.

14. *Papering,* or fixing them in the paper. This is done by children, who acquire the habit of putting up 36,000 per day.

The pin manufacture is one of the greatest prodigies of the division of labour; it furnishes 12,000 articles for the sum of three shillings, which have required the united diligence of fourteen skilful operatives.

The above is an outline of the mode of manufacturing pins by hand labour, but several beautiful inventions have been employed to make them entirely, or in a great measure, by machinery; the consumption for home sale and export amounting to 15 millions daily, for this country alone. One of the most elaborate, and apparently complete, is that for which Mr. L. W. Wright obtained a patent in May, 1824. A detailed description of it will be found in the 9th volume of *Newton's London Journal*. The following outline will give my readers an idea of the structure of this ingenious machine:—

The rotation of a principal shaft mounted with several cams, gives motion to various sliders, levers, and wheels, which work the different parts. A slider pushes pincers forwards, which draw wire from a reel, at every rotation of the shaft, and advance such a length of wire as will produce one pin. A dye cuts off the said length of wire by the descent of its upper chap; the chap then opens a carrier, which takes the pin to the pointing apparatus. Here it is received by a holder, which turns round, while a bevel-edged file-wheel rapidly revolves, and tapers the end of the wire to a point. The pin is now conducted by a second carrier to a finer file-wheel, in order to finish the point by a second grinding. A third carrier then transfers the pin to the first heading die, and by the advance of a steel punch, the end of the pin wire is forced into a recess, whereby the head is partially swelled out. A fourth carrier removes the pin to a second die, where the heading is perfected. When the heading-bar retires, a forked lever draws the finished pin from the die, and drops it into a receptacle below.

I believe the chief objection to the raising of the heads by strong mechanical compression upon the pins, is the necessity of softening the wire previously; whereby the pins thus made, however beautiful to the eye, are deficient in that stiffness which is so essential to their employment in many operations of the toilet.

Edeleston, and Williams, New Hall Works, Birmingham, Manufacturers. Pins, the heads and shafts being formed of one solid piece of metal, in order to render the head immovable and smooth in use, made by improved machinery. Model dies to show the formation of the head. Elastic hair-pins. Specimens of iron wire in various sizes. In pin making the wire is brass, (a compound of copper and zinc): it is reduced by the ordinary process of wire drawing to the requisite thickness: in this process it is necessarily curved. To remove this it is re-wound, and pulled through between a number of pins arranged at the draw or straightening bench; it is then cut into convenient lengths for removal, and finally reduced to just such a length as will make two pins. The pointing is done upon steel mills (revolving wheels), the circumference of which is cut with teeth, the one fine, the other coarse. Thirty or forty lengths are packed up at once, and, as in needle-making, the cast of hand given by the workman makes them revolve, and the whole are pointed at once; the same operation is performed with the other end. The process of heading is next performed as follows: a number of the pointed wires now cut in two, are placed in the feeder of the machine; one drops, is firmly seized, and by means of a pair of dies, a portion of the metal is forced up into a small bulb; by a beautifully simple and automatic arrangement, it is passed into another, when a small horizontal hammer gives it a sharp tap, which completes the head. The white colour is produced by boiling in a solution of cream of tartar and tin. They are then dried, and passed into the hands of the wrappers-up. The preparation or marking of the paper is peculiar, and is done by means of a moulded piece of wood, the moulds corresponding to those portions which represent the small folds of paper through which the pins are passed, and thereby held. The pins are then taken to the paperers, who are

each seated in front of a bench, to which is attached a horizontally hinged piece of iron the edge of which is notched with a corresponding number of marks to the number of pins to be stuck; the small catch which holds together the two parts of the iron is released, the paper introduced, and a pin inserted at every mark; the paper is then released, and the task of examination follows, which is the work of a moment. The paper of pins is held so that the light strikes upon it: those defective are immediately detected by the shade, are taken out, and others substituted in their stead. An ancient edict of Henry VIII., held that, "no one should sell any pins but such as were double-headed, or the heads soldered fast on."

Pins, Improved.—*The selection and preparation of the wire.*—The iron or steel wire employed should be very round, and, to protect it from rust, it should at the last drawing be lubricated by means of a sponge saturated with oil, placed between the draw-plate and reel. In all the subsequent stages of the manufacture, care should also be taken to preserve the pins from oxidation by keeping them well oiled and greased.

The cleansing and polishing.—The wire being cut into pins, and these headed and pointed, all according to the usual methods, the pins are thrown into a revolving cylinder of wood containing a bath of soap and water in a hot state. It is of the capacity of about 9½ gallons, but should not contain more than about 1½ gallons of water, with about 2 ounces of soap dissolved therein, as this quantity will be sufficient for the treatment of about 13½ lbs. weight of pins at a time. The cylinder, when thus charged, is made to revolve for about a quarter of an hour; at the expiration of which time the pins are found free from the oil with which they were previously coated, and also very much smoothed and polished by their rubbing one against the other.

The drying. The pins are next dried by transferring them to another cylinder partially filled with well dried sawdust (preferring for the purpose the sawdust of poplar wood), and causing this cylinder to revolve for about ten minutes; or, instead of employing a cylinder of this description, the pins may be thrown into a bag or bags partially filled with the sawdust, and the requisite friction produced by swinging or rolling these bags about for the same length of time.

The copper coating bath or mixture.—Into a glass or stone vase, the inventor puts about 1½ gallons of soft water, $\frac{1}{10}$ of a pound of sulphuric acid, $\frac{1}{10}$ lb. of salt of tin, $\frac{1}{10}$ lb. of crystallized sulphate of zinc, and 108 gra. of pure sulphate of copper, and leaves this mixture to work for about 24 hours, so that the salts and sulphates may be properly dissolved. This is found to be, on the whole, the mixture best adapted for the purpose in view; but most of the ingredients mentioned may have others substituted for them, as, for example, any other acid or substance producing like effects may be used instead of the sulphuric acid, or the sulphate of tin may be substituted for the salt of tin.

The copper coating process.—The mixture, prepared as last directed, is introduced into another revolving cylinder, and pins about 13½ lbs. weight are thrown into the midst of it. The cylinder is then caused to revolve for about half an hour, which serves at once to remove any verdigris from the pins to impart a high polish to them, and to give a beginning to the copper coating process. At the end of the half hour or thereabouts 232 gra. of crystallized sulphate of copper in coarse powder, and 150 gra. of crystallized sulphate of zinc, previously dissolved in soft water, are added to the mixture in the cylinder, and the whole again agitated for about a quarter of an hour. The pins are by this operation not only completely coated, but acquire a very considerable degree of polish. The copper liquors being drawn off, the pins are washed with cold water in the rotating cylinder, and afterwards in a tub with soap and water out of contact with air, where they are well shaken. The contents of the tub are then emptied into a wooden strainer, having a perforated bottom of tin plate iron. The pins are finally dried by agitation with dry sawdust.

The tinning and blanching are performed by laying the pins upon plates of very thin tin placed one above another, in a tinned copper boiler containing a solution of about 4½ lbs. of crude tartar or cream of tartar, in about 22 galls. of water, and then setting the whole to boil for about 12 hours. The tartar solution should be prepared at least 24 hours previously. A little more cream of tartar improves the brilliancy of the pins.

PIPERINE, is a crystalline principle extracted from black pepper, by means of alcohol. It is colourless, has hardly any taste, fuses at 212° F.; is insoluble in water, but soluble in acetic acid, ether, and most readily in alcohol.

PITCH, MINERAL, is the same as BITUMEN and ASPHALT.

PITCH of wood-tar (Pois, Fr.; Peck, Germ.); is obtained by boiling tar in an open iron pot, or in a still, till the volatile matters be driven off. Pitch contains pyrologinous resin, along with colophony (common rosin), but its principal ingredient is the former, called by Berzelius pyretine. It is brittle in the cold but softens and becomes ductile

with heat. It melts in boiling water, and dissolves in alcohol and oil of turpentine, as well as in carbonated or caustic alkaline lyes. For PYRAXINE, see the mode of preparing it from birch wood, for the purpose of preparing *Bessie* LEATHES.

PITCOAL. (*Houille*, Fr.; *Steinkohle*, Germ.) This is by far the most valuable of mineral treasures, and the one which, at least in Great Britain, makes all the others available to the use and comfort of man. Hence it has been searched after with unremitting diligence, and worked with many of the lights of science, and the resources of art.

The Brora coal-field in Sutherlandshire is the most remarkable example in this, or in perhaps any country hitherto investigated, of a pseudo coal-basin among the deeper secondary strata, but above the new sandstone or red marl formation. The Rev. Dr. Buckland and Sir C. Lyell, after visiting it in 1824, had expressed an opinion that the strata there were wholly unconnected with the proper coal formation below the new red sandstone, and were in fact the equivalent of the oolitic series; an opinion fully confirmed by the subsequent researches of Sir R. Murchison. (*Geol. Trans.* for 1827, p. 293.) The Brora coal-field forms a part of those secondary deposits which range along the south-east coast of Sutherlandshire, occupying a narrow tract of about twenty miles in length, and three in its greatest breadth.

One stratum of the Brora coal-pit is a coal-shale, composed of a reed-like striated plant of the natural order *Equisetum*, which seems to have contributed largely towards the formation of that variety of coal. From this coal-shale, the next transition upwards is into a purer bituminous substance approaching to jet, which constitutes the great bed of coal. This is from 3 feet 3 inches to 3 feet 8 inches thick, and is divided nearly in the middle by a thin layer of impure indurated shale charged with pyrites, which, if not carefully excluded from the mass, sometimes occasions spontaneous combustion upon exposure to the atmosphere; and so much indeed is that mineral disseminated throughout the district, that the shales might be generally termed "pyritiferous." Inattention on the part of the workmen, in 1817, in leaving a large quantity of this pyritous matter to accumulate in the pit, occasioned a spontaneous combustion, which was extinguished only by excluding the air; indeed the coal-pit was closed in and remained unworked for four years. The fires broke out again in the pit in 1827.

The purer part of the Brora coal resembles common pitcoal; but its powder has the red ferruginous tinge of pulverized lignites. It may be considered one of the last links between lignite and true coal, approaching very nearly in character to jet, though less tenacious than that mineral; and, when burnt, exhaling but slightly the vegetable odour so peculiar to all imperfectly bituminised substances. The fossil remains of shells and plants prove the Brora coal to be analogous to that of the eastern moorlands of Yorkshire, although the extraordinary thickness of the former, compared with any similar deposit of the latter (which never exceeds from 12 to 17 inches), might have formerly led to the belief that it was a detached and anomalous deposit of true coal, rather than a lignite of any of the formations above the new red sandstone: such misconception might more easily arise in the infancy of geology, when the strata were not identified by their fossil organic remains.

On the coast of Yorkshire the strata of this pseudo coal formation appear in the following descending order, from Filey Bay to Whitby. 1. Coral-rag. 2. Calcareous grit. 3. Shale, with fossils of the Oxford clay. 4. Kelloway rock (swelling out into an important arenaceous formation). 5. Cornbraeh. 6. Coaly grit of Smith. 7. Pierstone (according to Mr. Smith, the equivalent of the great oolite). 8. Sandstone and shale, with peculiar plants and various seams of coal. 9. A bed with fossils of the inferior oolite. 10. Marl-stone? 11. Alum-shale or lia. All the above strata are identified by abundant organic remains.

In the oolitic series, therefore, where the several strata are developed in conformity with the more ordinary type of these formations, we may venture to predict with certainty, that no carboniferous deposits of any great value will ever be discovered, at all events in Great Britain. A want of such knowledge has induced many persons to make trials for coal in beds subordinate to the English oolites, and even superior to them, in places where the type of formation did not offer the least warrant for such attempts.

The third great class of terrestrial strata, is the proper coal-measures, called the *carboniferous rocks*, our leading object here, and to which we shall presently return.

The transition rocks which lie beneath the coal-measures, and above the primitive rocks, or are anterior to the carboniferous order, and posterior to the primitive, contain a peculiar kind of coal, called anthracite or stone-coal, approaching closely in its nature to carbon. It is chiefly in the transition clay-slate that the anthracite occurs in considerable masses. There is one in the transition slate of the little Saint Bernard, near the village of *la Thuile* (in the Alps). It is 100 feet long, and 2 or 3 yards thick.

The coal burns with difficulty, and is used only for burning lime. There are several of the same kind in that country, which extend down the reverse slope of the mountains looking to Savoy. The slate enclosing them presents vegetable impressions of reeds or analogous plants. To the transition clay-slate we must likewise refer the beds of anthracite that M. Hericart de Thury observed at very great heights in the Alps of Dauphiny, in a formation of schist and grey-wacke with vegetable impressions, which reposes directly on the primitive rocks.

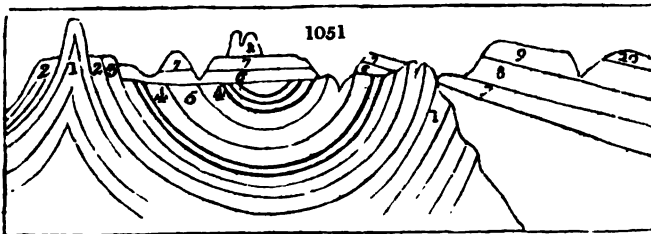
The great carboniferous formation may be subdivided into four orders of rocks: 1. the coal-measures, including their manifold alternations of coal-beds, sandstones, and shales; 2. the millstone grit and shale towards the bottom of the coal-measures; 3. the carboniferous limestone, which projecting to considerable heights above the outcrop of the coal and grit, acquires the title of mountain limestone; 4. the old red sandstone, or connecting link with the transition and primary rock basin in which the coal system lies.

The coal-fields of England, from geographical position, naturally fall under the following arrangement: — 1. The *great northern district*; including all the coal-fields north of Trent. 2. The *central district*; including Leicester, Warwick, Stafford, and Shropshire. 3. The *western district*; subdivided into *north-western*, including North Wales, and the *south-western*, including South Wales, Gloucester, and Somersetshire.

There are three principal coal-basins in Scotland: 1. that of Ayrshire; 2. that of Clydesdale; and 3. that of the valley of the Forth, which runs into the second in the line of the Union Canal. If two lines be drawn, one from Saint Andrews on the north-east coast, to Kilpatrick on the Clyde, and another from Aberlady, in Haddingtonshire, to a point a few miles south of Kirkoswald in Ayrshire, they will include between them the whole space where pitcoal has been discovered and worked in Scotland.

The great coal-series consists of a regular alternation of mineral strata deposited in a great concavity or basin, the sides and bottom of which are composed of transition rocks. This arrangement will be clearly understood by inspecting *fig. 1051.*, which represents a section of the coal-field south of Malmsbury.

Mendip hills. Dundry hill. Wick rocks. Fog hill, N. of Lansdowne.



1, 1, old red sandstone; 2, mountain limestone; 3, millstone grit; 4, 4, coal seams; 5, Pennant, or coarse sandstone; 6, new red sandstone, or red marl; 7, 7, lias; 8, 8, inferior oolite; 9, great oolite; 10, cornbrash and Forest marble.

No. 1., or the old red sandstone, may therefore be regarded as the characteristic lining of the coal basins; but this sandstone rests on transition limestone, and this limestone on grey-wacke. This methodical distribution of the carboniferous series is well exemplified in the coal-basin of the Forest of Dean in the south-west of England, and has been accurately described by Mr. Mushet.

The *grey-wacke* consists of highly inclined beds of slaty micaceous sandstone, which on the one hand alternates with and passes into a coarse breccia, having grains as large as peas; on the other, into a soft argillaceous slate. The grey-wacke stands bare on the north-eastern border of the Forest, near the southern extremity of the chain of transition limestone, which extends from Stoke Edith, near Hereford, to Flaxley on the Severn. It is traversed by a defile, through which the road from Gloucester to Ross winds. The abruptness of this pass gives it a wild and mountainous character, and affords the best opportunity of examining the varieties of the rock.

The *Transition limestone* consists in its *lower beds* of fine-grained, tender, extremely argillaceous slate, known in the district by the name of *water-stone*, in consequence of the wet soil that is found wherever it appears at the surface. Calcareous matter is interspersed in it but sparingly. Its *upper beds* consist of shale alternating with extensive beds of stratified limestone. The lowest of the calcareous strata are thin, and alternate with shale. On these repose thicker strata of more compact limestone, often of a dull blue colour. The beds are often dolomitic, which is indicated by straw yellow colour, or dark pink colour, and by the sandy or glimmering aspect of the rock.

The *old red sandstone*, whose limits are so restricted in other parts of England, here

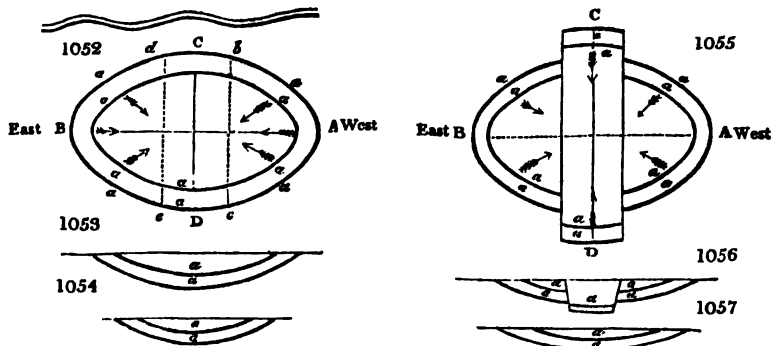
occupies an extensive area. The space which it covers, its great thickness, its high inclination, the abrupt character of the surface over which it prevails, and the consequent display of its strata in many natural sections, present in this district advantages for studying the formation, which are not to be met with elsewhere in South Britain. In the neighbourhood of Mitchel Dean, the total thickness of this formation, interposed conformably between the transition and mountain limestone, is from 600 to 800 fathoms. The old red sandstone is characterized in its upper portion by the presence of siliceous conglomerate, containing siliceous pebbles, which is applied extensively to the fabrication of millstones near Monmouth, and on the banks of the Wye. This sandstone encircles the Forest with a ring of very elevated ground, whose long and lofty ridges on the eastern frontier overhang the valley of the Severn.

The *mountain limestone*, or carboniferous, is distinguished from transition limestone, rather by its position than by any very wide difference in its general character or organic remains. According to the measurements of Mr. Musket, the total thickness of the mountain limestone is about 120 fathoms. The zone of limestone belonging to this coal-basin, is from a furlong to a mile in breadth on the surface of the ground, according as the dip of the strata is more or less rapid. The angle of dip on the northern and western border is often no more than 10°, but on the eastern it frequently amounts to 80°. The calcareous zone that defines the outer circle of the basin, suffers only one short interruption, scarcely three miles in length, where in consequence of a fault the limestone disappears, and the coal-measures are seen in contact with the old red sandstone.

Coal measures.—Their aggregate thickness amounts, according to Mr. Musket, to about 500 fathoms. 1. The lowest beds, which repose on the mountain limestone, are about 40 fathoms thick, and consist here, as in the Bristol coal-basin, of a red siliceous grit, alternating with conglomerate, used for millstones; and with clay, occasionally used for ochre. 2. These beds are succeeded by a series about 120 fathoms thick, in which a grey gritstone predominates, alternating in the lower part with shale, and containing 6 seams of coal. The grits are of a fissile character, and are quarried extensively for flag-stone, ashlers, and fire-stone. 3. A bed of grit, 25 fathoms thick, quarried for hearth-stone, separates the preceding series from the following, or the 4th, which is about 115 fathoms thick, and consists of from 12 to 14 seams of coal alternating with shale. 5. To this succeeds a straw-coloured sandstone, nearly 100 fathoms thick, forming a high ridge in the interior of the basin. It contains several thin seams of coal, from 6 to 16 inches in thickness. 6. On this reposes a series of about 12 fathoms thick, consisting of 3 seams of coal alternating with shale. 7. This is covered with alternate beds of grit and shale, whose aggregate thickness is about 100 fathoms, occupying a tract in the centre of the basin about 4 miles long, and 2 miles broad. The sandstone No. 5. is probably the equivalent of the Pennant in the preceding figure.

The floor, or pavement, immediately under the coal beds is, almost without exception, a grayish-slate clay, which, when made into bricks, strongly resists the fire. This fire-clay varies in thickness from a fraction of an inch to several fathoms. Clay-ironstone is often disseminated through the shale.

The most complete and simplest form of a coal-field is the entire basin-shape, which we find in some instances without a dislocation. A beautiful example of this is to be seen at Blairrengone, in the county of Perth, immediately adjoining the western boundary of Clackmannanshire, as represented in *fig. 1052.*, where the outer elliptical line, marked



A, B, C, D, represents the crop, outburst, or basset edge of the lower coal, and the inner elliptical line represents the crop or basset edge of the superior coal. *Fig. 1053.* is the

longitudinal section of the line *A B*; and *fig.* 1054, the transverse section of the line *C N*. All the accompanying coal strata partake of the same form and parallelism. These basins are generally elliptical, sometimes nearly circular, but are often very eccentric, being much greater in length than in breadth; and frequently one side of the basin on the short diameter has a much greater dip than the other, which circumstance throws the trough or lower part of the basin concavity much nearer to the one side than to the other. From this view of one entire basin, it is evident that the dip of the coal strata belonging to it runs in opposite directions, on the opposite sides, and that all the strata regularly crop out, and meet the alluvial cover in every point of the circumferential space, like the edges of a nest of common basins. The waving line marks the river Devon.

It is from this basin shape that all the other coal-fields are formed, which are segments of a basin produced by slips, dikes, or dislocations of the strata. If the coals (*fig.* 1052.) were dislocated by two slips *b c* and *d e*, the slip *b c* throwing the strata *down* to the east, and the slip *d e* throwing them as much *up* in the same direction, the outcrops of the coals would be found in the form represented in *fig.* 1055., of which *fig.* 1056, is the section in the line *A B*, and *fig.* 800. the section in the line *C N*.

The chief difficulty in exploring a country in search of coal, or one where coal-fields are known to exist, arises from the great thickness of alluvial and other cover, which completely hides the outcrop or basset edge of the strata, called by miners the *rock-head*; as also the fissures, dikes, and dislocations of the strata, which so entirely change the structure and bearings of coal-fields, and cause often great loss to the mining adventurer. The alluvial cover on the other hand is beneficial, by protecting the seams of the strata from the superficial waters and rains, which would be apt to drown them, if they were naked. In all these figures of coal-basins, the letter *a* indicates coal.

The absolute shape of the coal-fields in Great Britain has been ascertained with surprising precision. To whatever depth a coal-mine is drained of its water, from that depth it is worked, up to the rise of the water-level line, and each miner continues to advance his room or working-place, till his seam of coal meets the alluvial cover of the outcrop, or is cut off by a dislocation of the strata. In this way the miner travels in succession over every point of his field, and can pourtray its basin-shape most minutely.

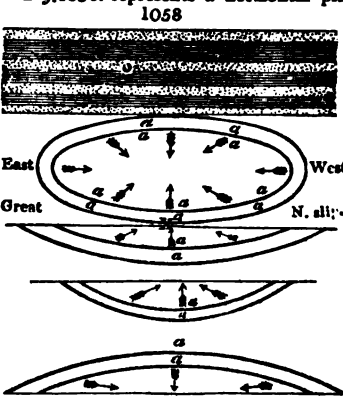
Fig. 1058. represents a horizontal plan of the Clackmannanshire coal-field, as if the strata at the outcrop all around were denuded of the alluvial cover. Only two of the concentric beds, or of their edges *a, a*, are represented, to avoid perplexity. It is to be remembered, however, that all the series *c f* attendant strata lie parallel to the above line.

This plan shows the Ochill mountains, with the north coal-fields, of an oblong elliptical shape, the side of the basin next the mountains being precipitous, as if upheaved by the eruptive trap-rocks; while the south, the east, and the west edges of the basin shelve out at a great distance from the lower part of the concavity or *trough*, as miners call it. Thus the alternate beds of coal, shale, and sandstone, all nearly concentric in the north coal-field, dip inwards from all sides towards the central area of the *trough*. The middle coal-field of this district, however, which is formed by the great north slip, is merely the segment of an elliptical

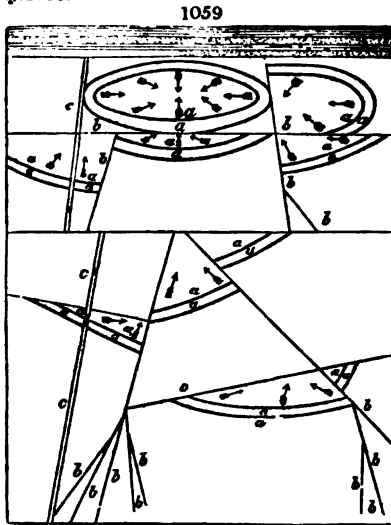
basin, where the strata dip in every direction to the middle of the axis marked with the letter *x*; being the deepest part of the segment. The south coal-field, formed by the great south slip, is likewise the segment of another elliptical basin, similar in all respects to the middle coal-field. Beyond the outcrop of the coals and subordinate strata of the south coal-fields, the counter dip of the strata takes place, producing the mantle-shaped form; whence the coal strata in the Dunmore field, in Stirlingshire, lie in a direction contrary to those of the south coal-field of Clackmannanshire. *o*, are the Ochill mountains.

Fig. 1059. is intended to represent an extensive district of country, containing a great coal-basin, divided into numerous subordinate coal-fields by these dislocations. The lines marked *b* are slips, or faults; the broad lines marked *e* denote dykes: the former dislocate the strata, and change their level, while dykes disjoin the strata with a wall, but do not in general affect their elevation. The two parallel lines marked *a*, represent two seams of coal, variously heaved up and down by the faults; whereas the dykes are seen to pass through the strata without altering their relative position. In this manner, partial coal-fields are distributed over a wide area of country, in every direction.

The only exception to this general form of the coal-fields in Great Britain, is the in-



verted basin shape; but this is rare. A few examples occur in some districts of England, and in the county of Fife; but even in extensive coal-fields, this convex form is but a partial occurrence, or a deviation by local violence from the ordinary basin. Fig. 1060. is an instance of a convex coal-field exhibited in Staffordshire, at the Castle-hill, close to the town of Dudley.



1, 1, are limestone strata; 2, 2, are coal. Through this hill, canals have been cut, for working the immense beds of carboniferous limestone. These occur in the lower series of the strata of the coal-field, and therefore at a distance of many miles from the Castle-hill, beyond the outcrop of all the workable coals in the proper basin-shaped part of the field; but by this apparently inverted basin-form, these limestone beds are elevated far above the level of the general surface of the country, and consequently above the level of all the coals. We must regard this seeming inversion as resulting from the approximation of two coal-basins, separated by the baset edges of their mountain limestone repository.

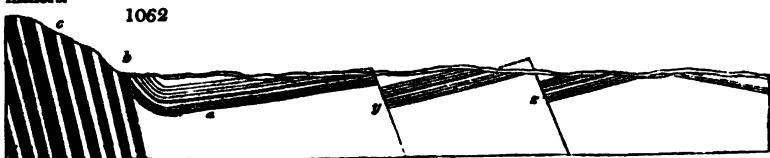
Fig. 1061. is a vertical section of the Dudley coal-basin, the upper coal-bed of which has the astonishing thickness of 30 feet; and this mass extends 7 miles in length, and 4 in in breadth. Coal-seams 5 or 6 feet thick, are called *this* in that district.



Fig. 1062. is a very interesting section of the main coal-basin of Clackmannanshire, as given by Mr. Bald in the Wernerian Society's Memoirs, vol. iii. Here we see it broken into three sub-

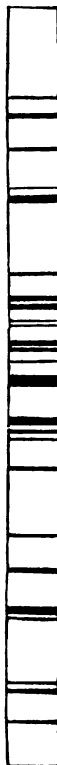
ordinate coal-fields, formed by two great faults or dislocations of the strata; but independently of these fractures across the whole series, the strata continue quite regular in their respective alternations, and preserve nearly unchanged their angle of inclination to the horizon. The section shows the south coal-field dipping northerly, till it is cut across by the great south slip *x*, which dislocates the coal and the parallel strata to the enormous extent of 1230 feet, by which all the coals have been thrown up, not simply to the day, but are not found again till we advance nearly a mile northward, on the line of the dip, where the identical seams of coal, shale, &c. are observed once more with their regular inclination. These coals of the middle area, dip regularly northward till interrupted by the great north slip *y*, which dislocates the strata, and throws them up 700 feet; that is to say, a line prolonged in the direction of any one well-known seam, will run 700 feet above the line of the same seam as it emerges after the middle slip. Immediately adjoining the north slip, the coals and coal-field resume their course, and dip regularly northward, running through a longer range than either of the other two members of the basin, till they arrive at the valley of the Devon, at the foot of the Ochill mountains, where they form a concave curvature, or trough, *a*, and thence rise rapidly in an almost vertical direction at *b*. Here the coals,

with all their associate strata, assume conformity and parallelism with the face of the sienitic-greenstone strata of the Ochill mountains *c*; being raised to the high angle of 73 degrees with the horizon. The coal-seams thus upheaved, are called *edge-metals* by the miners.



In this remarkable coal-field, which has been accurately explored by pitting and boring to the depth of 703 feet, there are no fewer than 142 beds, or distinct strata of coal, shale, and sandstone, &c., variously alternating, an idea of which may be had

1063

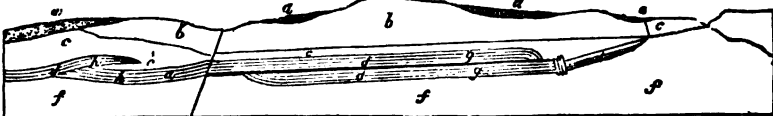


by inspecting *fig. 1063*. Among these are 24 beds of coal, which would constitute an aggregate thickness of 59 feet 4 inches; the thinnest seam of coal being 2 inches, and the thickest 9 feet. The strata of this section contain numerous varieties of sandstone, slate-clay, bituminous shale, indurated clay, or fire-clay, and clay ironstone. Neither trap-rock nor limestone is found in connexion with the workable coals; but an immense bed of greenstone, named *Abbey Craig*, occurs in the western boundary of Clackmannanshire, under which lie regular strata of slate-clay, sandstone, thin beds of limestone, and large spheroidal masses of clay ironstone, with a mixture of lime.

"With regard to slips in coal fields," says Mr. Bald, "we find that there is a general law connected with them as to the position of the dislocated strata, which is this:—When a slip is met with in the course of working the mines— if when looking to it, the vertical line of the slip or fissure, it forms an acute angle with the line of the pavement upon which the observer stands, we are certain that the strata are dislocated downwards upon the other side of the fissure. On the contrary, if the angle formed by the two lines above mentioned is obtuse, we are certain that the strata are dislocated or thrown upwards upon the other side of the fissure. When the angle is 90°, or a right angle, it is altogether uncertain whether the dislocation throws up or down on the opposite side of the slip. When dikes intercept the strata, they generally only separate the strata the width of the dike, without any dislocation, either up or down; so that if a coal is intercepted by a dike, it is found again by running a mine directly forward, corresponding to the angle or inclination of the coal with the horizon."— *Wernerian Society's Memoirs*, vol. iii. p. 133.*

The Johnstone coal-field, in Renfrewshire, is both singular and interesting. The upper stratum of rock is a mass of compact greenstone or trap, above 100 feet in thickness, not at all in a conformable position with the coal strata, but overlying; next there is a few fathoms of soft sandstone and slate-clay, alternating, and uncommonly soft. Beneath these beds, there are no fewer than ten seams of coal, lying on each other, with a few divisions of dark indurated clay. These coal-seams have an aggregate thickness of no less than 100 feet; a mass of combustible matter, in the form of coal, unparalleled for its accumulation in so narrow a space. The greater part of this field contains only 5 beds of coal; but at the place where the section shown in *fig. 1064*, is taken, these 5 coals seem to have been overlapped or made to slide over each other by violence. This structure is represented in *fig. 1065*, which is a section of the Quarrelton coal in the Johnstone field, showing the overlapped coal and the double coal, with the thick bed of greenstone, overlying the coal-field.

1065



- a. Alluvial cover.
- b. Bed of trap or greenstone.
- c. Alternating coal strata.
- d. Coal-seams.
- e. Position of greenstone, not ascertained
- f. Strata in which no coals have been found.
- g. The overlapped coal.
- h. The double coal.

Before proceeding to examine the modes of working coal, I shall introduce here a description of the two principal species of this mineral.

1. *Cubical coal*.—It is black, shining, compact, moderately hard, but easily frangible. When extracted in the mine, it comes out in rectangular masses, of which the smaller fragments are cubical. The lamellæ (reed of the coal) are always parallel to the bed or plane on which the coal rests; a fact which holds generally with this substance. There are two varieties of cubical coal; the *open-burning* and the *caking*. The latter, however small its fragments may be, is quite available for fuel, in consequence of its agglutinating into a mass at a moderate heat, by the abundance of its bitumen. This kind is the true smithy or forge-coal, because it readily forms itself into a vault round the blast of the bellows, which serves for a cupola in concentrating the heat on objects thrust into the cavity.

The open-burning cubical coals are known by several local names; the rough coal or

* This paper does honour to its author, the eminent coal-viewer of Scotland

clod coal, from the large masses in which they may be had; and the cherry coal, from the cheerful blage with which they spontaneously burn; whereas the caking coals, such as most of the Newcastle qualities, require to be frequently poked in the grate. Its specific gravity varies from 1.25 to 1.4.

2. *Slate or splint coal.* — This is dull-black, very compact, much harder, and more difficultly frangible than the preceding. It is readily fissile, like slate, but powerfully resists the cross fracture, which is conchoidal. Specific gravity from 1.26 to 1.40. In working, it separates in large quadrangular sharp-edged masses. It burns without caking, produces much flame and smoke, unless judiciously supplied with air, and leaves frequently a considerable bulk of white ashes. It is the best fuel for distilleries and all large grates, as it makes an open fire, and does not clog up the bars with glassy scoriae. I found good splint coal of the Glasgow field to have a specific gravity of 1.266, and to consist of—carbon, 70.9; hydrogen, 4.3; oxygen, 24.8.

3. *Cannel coal.* — Colour between velvet and grayish-black; lustre resinous; fracture even; fragments trapezoidal; hard as splint coal; spec. grav. 1.23 to 1.28. In working, it is detached in four-sided columnar masses, often breaks conchoidal, like pitch, kindles very readily, and burns with a bright white projective flame, like the wick of a candle, whence its name. It occurs most abundantly in the coal-field of Wigan, in Lancashire, in a bed 4 feet thick; and there is a good deal of it in the Clydesdale coal-field, of which it forms the lowest seam that is worked. It produces very little dust in the mine, and hardly soils the fingers with carbonaceous matter. Cannel coal from Woodhall, near Glasgow, spec. grav. 1.228, consists by my analysis of—carbon, 72.29; hydrogen, 3.93; oxygen, 21.05; with a little azote (about 2.8 in 100 parts). This coal has been found to afford, in the Scotch gas-works, a very rich-burning gas. The azote is there converted into ammonia, of which a considerable quantity is distilled over into the tar-pit.

4. *Glance coal.* — This species has an iron-black colour, with an occasional iridescence, like that of tempered steel; lustre in general splendid, shining, and imperfect metallic; does not soil; easily frangible; fracture flat conchoidal; fragments sharp-edged. It burns without flame or smell, except when it is sulphureous; and it leaves a white-coloured ash. It produces no soot, and seems, indeed, to be merely carbon, or coal deprived of its volatile matter or bitumen, and converted into coke by subterranean calcination, frequently from contact with whin-dikes. Glance coal abounds in Ireland, under the name of Kilkenny coal; in Scotland it is called blind coal, from its burning without flame or smoke; and in Wales, it is the malting or stone coal. It contains from 90 to 97 per cent. of carbon. Specific gravity from 1.3 to 1.5; increasing with the proportion of earthy impurities.

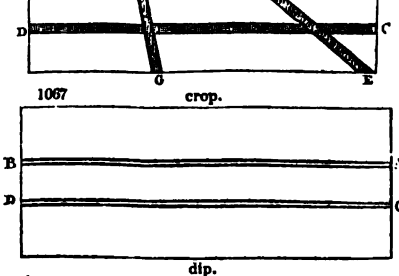
The dislocations and obstructions found in coal-fields, which render the search for coal so difficult, and their mining so laborious and uncertain, are the following:—

1. *Dikes.* 2. *Slips or Faults.* 3. *Hitches.* 4. *Troubles.*

The first three infer dislocation of the strata; the fourth changes in the bed of coal itself. 1. A dike is a well of extraneous matter, which divides all the beds in a coal-field.

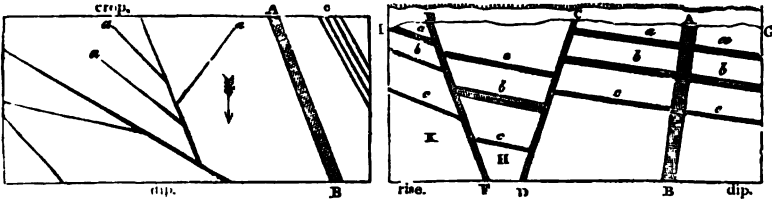
Dikes extend not only in one line of bearing through coal-fields for many miles, but run sometimes in different directions, and have often irregular bendings, but no sharp angular turns. When from a few feet to a few fathoms in thickness, they occur sometimes in numbers within a small area of a coal basin, running in various directions, and even crossing each other. Fig. 1066, represents a ground plan of a coal-field, intersected with greenstone dikes. A B and C D are two dikes standing parallel to each other; E F and C H are cross or oblique dikes, which divide both the coal strata and the primary dikes A B and C D.

2. *Slips or faults* run in straight lines through coal-measures, and at every angle of incidence to each other. Fig. 1067, represents a ground plan of a coal-field, with two slips A B and C D in the line of bearing of the planes of the strata, which throw them down to the outcrop. This is the simplest form of a slip. Fig. 1068, exhibits part of a coal-field intersected with slips, like a cracked sheet of ice. Here A B is a dike; while the narrow lines show faults of every kind, producing dislocations varying in amount of slip from a few feet to a great many fathoms. The faults at the points a, a, a vanish; and the lines at c denote four small partial slips called *hitches*.



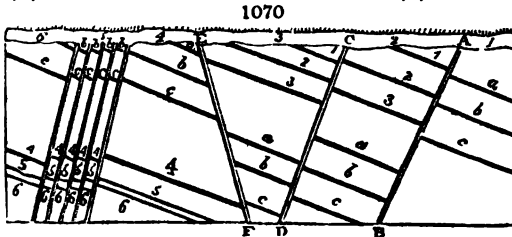
1066
H F
A B
C D
E
1067
crop.
B A
D C
dip.
1068
a a a
c

The effects of slips and dikes on the coal strata appear more prominently when viewed in a vertical section, than in a ground plan, where they seem to be merely walls, veins, and lines of demarcation. *Fig. 1069.* is a vertical section of a coal-field, from dip



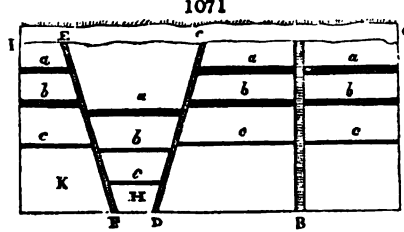
to rise, showing three strata of coal *a, b, c.* *AB* represents a dike at right angles to the plane of the coal-beds. This rectangular wall merely separates the coal-measures, affecting their line of rise; but further to the rise, the oblique dike *CD* interrupts the coals *a, b, c,* and not only disjoins them, but throws them and their concomitant strata greatly lower down; but still, with this depression, the strata retain their parallelism and general slope. Nearer to the outcrop, another dike *EF,* interrupts the coals *a, b, c,* not merely breaking the continuity of the planes, but throwing them moderately up, so as to produce a steeper inclination, as shown in the figure. It sometimes happens that the coals in the compartment *X,* betwixt the dikes *c* and *x,* may lie nearly horizontal, and the effect of the dike *EF,* is then to throw out the coals altogether, leaving no vestige of them in the compartment *X.* "Such," says Mr. Bald, from whom these illustrations are borrowed, "are the most prominent changes in the strata, as to their line of direction, produced by dikes; but of these changes there are various modifications."

The effect of slips on the strata is also represented in the vertical section, *fig. 1070,* where *a, b, c* are coals with their associated strata. *A, B,* is an intersecting slip, which throws all the coals of the first compartment much lower, as is observable in the second,

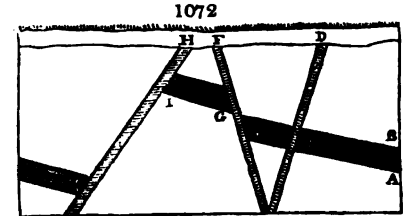


No. 2; and from the amount of the slip, it brings in other coal-seams, marked 1, 2, 3, not in the compartment No. 1. *c, d,* is a slip producing a similar result, but not of the same magnitude. *EF,* represents a slip across the strata, reverse in direction

to the former; the effect of which is to throw up the coals, as shown in the area No. 4. Such a slip occasionally brings into play seams seated under those marked *a, b, c,*



as seen at 4, 5, 6; and it may happen that the coal marked 4 lies in the prolongation of a well-known seam, as *c,* in the compartment No. 3, when the case becomes puzzling to the miner. In addition to the above varieties, a number of slips or hitches are often seen near one another, as in the area marked No. 5., where the individual displacements are inconsiderable, but the aggregate dislocation may be great, in reference to the seams of the 6th compartment.



The results of dikes and slips on a horizontal portion of a field are exemplified in *fig. 1071.* Where the coal-measures are horizontal, and the faults run at a greater angle than 45° to the line of bearing, they are termed dip and rise faults, as *A, B, C, D, E, F.*

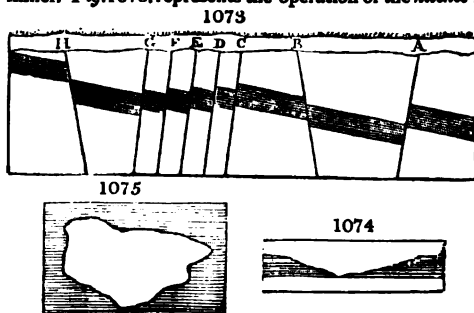
Coal viewers or engineers regard the dislocations now described as being subject in one respect to a general law, which may be thus explained:—Let *fig. 1072.*

be a portion of a coal-measure; Δ , being the pavement and π the roof of the coal-seam. If, in pursuing the stratum at c , a dike ν occurs, standing at right angles with the pavement, they conclude that the dike is merely a partition-wall between the beds by its own thickness, leaving the coal-seam underanged on either side; but if a dike r forms, as at π , an obtuse angle with the pavement, they conclude that the dike is not a simple partition between the strata, but has thrown up the several seams into the predicament shown at a . Finally, should a dike μ make at i an acute angle with the pavement, they conclude that the dike has thrown down the coal-measures into the position of κ .

The same important law holds with slips, as I formerly stated; only when they form right angles with the pavement, the case is ambiguous; that is, the strata may be dislocated either upwards or downwards.

Dikes and faults are denominated upthrow or downthrow, according to the position they are met with in working the mine. Thus, in *fig. 1069*, if the miner is advancing to the rise, the dike Δ , ν obviously does not change the direction; but c , ν is a downthrow dike of a certain number of fathoms towards the rise of the basin, and π , r is an upthrow dike likewise towards the rise. On the other hand, when the dikes are met with by the miner in working from the rise to the dip, the names of the above dikes would be reversed; for what is an upthrow in the first case, becomes a downthrow in the second, relative to the mining operations.

3. We have seen that *hitches* are small and partial slips, where the dislocation does not exceed the thickness of the coal-seam; and they are correctly enough called *steps* by the miner. *Fig. 1073*, represents the operation of the *hitches* Δ , ν , c , d , π , r , a , κ , on the coal-measures. Though observed in one



or two seams of a field, they may not appear in the rest, as is the case with dikes and faults.

4. *Troubles* in coal-fields are of various kinds.

1. *Irregular layers of sandstone*, appearing in the middle of the coal-seam, and gradually increasing in thickness till they separate the coal into two distinct seams, too thin to continue workable.

2. *Nips*, occasioned by the gradual approximation of the

roof and pavement, till not a vestige of coal is left between them; the softer shale disappearing also at the same time. *Figs. 1074*, & *1075*, represent this accident, which is fortunately rare; the first being a vertical, and the second a horizontal view.

3. *Shaken coal*. It resembles the rubbish of an old waste, being a confused heap of coal-dust, mixed with small pieces of cubical coal, so soft that it can frequently be dug with the spade. This shattering is analogous to that observed occasionally in the flint nodules of the chalk formation; and seems like the effect of some electric tremor of the strata.

In searching for coal in any country, its concomitant rocks ought to be looked for, especially the carboniferous or mountain limestone, known by its organic fossils; (see *Ure's Geology*, p. 175, and corresponding plate of fossils;) likewise the outcrop of the millstone grit, and the newer red sandstone, among some rifts or *façades* of which, seams of coal may be discerned. But no assurance of coal can be had without boring or pitting.

Skill in boring judiciously for coal, distinguishes the genuine miner from the empirical adventurer, who, ignorant of the general structure of coal-basins, expends labour, time, and money at random, and usually to no purpose; missing the proper coal-field, and leading his employer to sink a shaft where no productive seams can be had. A skilful viewer, therefore, should always direct the boring operations, especially in an unexplored country.

The boring rods should be made of the best and most tenacious Swedish iron; in area, about an inch and a quarter square. Each rod is usually 3 feet long, terminating in a male screw at one end, and a female screw at the other. The boring chisels are commonly 18 inches long, and from 2 inches and a half to 3 inches and a quarter at their cutting edge, which must be tipped with good steel. The chisel is screwed to an intermediate 18-inch rod, called the double box-rod, forming together a rod 3 feet long. There are, moreover, three short rods, a foot, 18 inches, and 2 feet long each, which may be screwed, as occasion requires, to the brace-head, to make the height above the

mouth of the bore convenient for the hands of the men in working the rods. Hence the series of rods becomes a scale of measurement for noting the depth of the bore, and keeping a journal of the strata that are perforated. The brace-head rod, also 18 inches long, has two large eyes or rings at its top, set at right angles to each other, through which arms of wood are fixed for the men to lift and turn the rods by, in the boring process.

When the bore is intended to penetrate but a few fathoms, the whole work may be performed directly by the hands; but when the bore is to be of considerable depth, a lofty triangle of wood is set above the bore-hole, with a pulley depending at its summit angle, for conducting the rope to the barrel of a windlass or wheel and axle, secured to the ground with heavy stones. The loose end of the rope is connected to the rods by an oval iron ring, called a runner; and by this mechanism they may be raised and let fall in the boring; or the same effect may be more simply produced by substituting for the wheel and axle, a number of ropes attached to the rod-rope, each of which may be pulled by a man, as in raising the ram of the pile-engine.

In the Newcastle coal district there are professional master-borers, who undertake to search for coal, and furnish an accurate register of the strata perforated. The average price of boring in England or Scotland, where no uncommon difficulties occur, is six shillings for each of the first five fathoms, twice 6 shillings for each of the second five fathoms, thrice 6 shillings for each of the third five fathoms, and so on; hence the series will be —

| | | | | | | | | | | |
|--------------------|---|---|---|---|----------|---|---|---|---|-------|
| 1st five fathoms | - | - | - | - | 6s. each | - | - | - | - | £1 10 |
| 2nd five fathoms | - | - | - | - | 12s. — | - | - | - | - | 3 0 |
| 3rd five fathoms | - | - | - | - | 18s. — | - | - | - | - | 4 10 |
| 4th five fathoms | - | - | - | - | 24s. — | - | - | - | - | 6 0 |
| <hr/> | | | | | | | | | | |
| 20 fathoms of bore | - | - | - | - | - | - | - | - | - | £15 0 |

Thus the price increases equally with the depth and labour of the bore, and the undertaker usually upholds his rods. There are peculiar cases, however, in which the expense greatly exceeds the above rate.

The boring tools are represented in the following figures:—

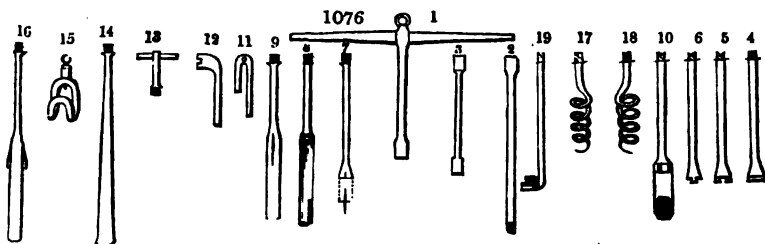


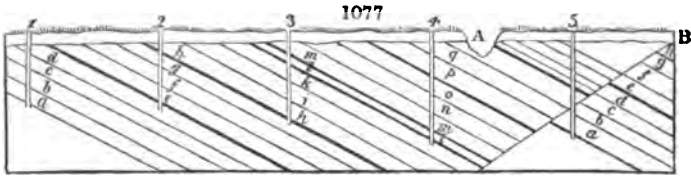
Fig. 1076.

- | | |
|---|---|
| <ol style="list-style-type: none"> 1. The brace-head. 2. The common rod. 3. The double-box rod; intermediate piece. 4. The common chisel. 5. The indented chisel. 6. Another of the same. 7. The cross-mouthed chisel. 8. The wimble. 9. The sludger, for bringing up the mud. 10. The rounder. | <ol style="list-style-type: none"> 11. The key for supporting the train of rods at the bore-mouth. 12. The key for screwing together and asunder the rods. 13. The topit, or top-piece. 14. The beché, for catching the rod when it breaks in the bore. 15. The runner, for taking hold of the topit. 16. The tongued chisel. 17. The right-handed worm screw. 18. The left-handed do. 19. The finger-grip or catch. |
|---|---|

We shall now explain the manner of conducting a series of bores in searching ground for coal.

Fig. 1077. represents a district of country in which a regular survey has proved the existence and general distribution of coal strata, with a dip to the south, as here shown. In this case, a convenient spot should be pitched upon in the north part

of the district, so that the successive bores put down may advance in the line of the



dip. The first bore may therefore be made at No. 1., to the depth of sixty yards. In the progress of this perforation, many diversities and alternations of strata will be probably passed through, as we see in the sections of the strata; each of which, as to quality and thickness, is noted in the journal, and specimens are preserved. This bore is seen to penetrate the strata *d*, *c*, *b*, *a*, without encountering any coal. Now, suppose that the dip of the strata be one yard in ten, the question is, at what distance from bore No. 1. in a south direction, will a second bore of 60 yards strike the first stratum *d*, of the preceding? The rule obviously is, to multiply the depth of the bore by the dip, that is, 60 by 10, and the product 600 gives the distance required; for, by the rule of three, if 1 yard of depression corresponds to 10 in horizontal length, 60 yards of depression will correspond to 600 in length. Hence the bores marked 1, 2, 3, 4, and 5, are successively distributed as in the figure, the spot where the first is let down being regarded as the point of level to which the summits of all the succeeding bores are referred. Should the top of No. 2. bore be 10 yards higher or lower than the top of No. 1., allowance must be made for this difference in the operation; and hence a surface level survey is requisite. Sometimes ravines cut down the strata, and advantage should be taken of them, when they are considerable.

In No. 2. a coal is seen to occur near the surface, and another at the bottom of the bore; the latter seam resting on the first stratum *d*, that occurred in bore No. 1.; and No. 2. perforation must be continued a little farther, till it has certainly descended to the stratum *d*. Thus these two bores have, together, proved the beds to the depth of 120 yards.

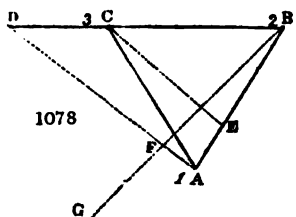
No. 3. bore being placed according to the preceding rule, will pass through two coal-seams near the surface, and after reaching to nearly its depth of 60 yards, it will touch the stratum *h*, which is the upper stratum of bore No. 2.; but since a seam of coal was detected in No. 2., under the stratum *h*, the proof is confirmed by running the borer down through that coal. The field has now been probed to the depth of 180 yards. The fourth bore is next proceeded with, till the two coal-seams met in No. 3. have been penetrated; when a depth of 240 yards has been explored. Hence No. 4. bore could not reach the lower stratum *a*, unless it were sunk 240 yards.

The fifth bore (No. 5.) being sunk in like manner, a new coal-seam occurs within a few yards of the surface; but after sinking to the depth at which the coal at the top of the fourth bore was found, an entirely different order of strata will occur. In this dilemma, the bore should be pushed 10 or 20 yards deeper than the 60 yards, to ascertain the alternations of the new range of superposition. It may happen that no coals of any value shall be found, as the figure indicates, in consequence of a slip or dislocation of the strata at *x*, which has thrown up all the coals registered in the former borings, to such an extent that the strata *b*, *a*, of the first bore present themselves immediately on perforating the slip, instead of lying at the depth of 300 yards (5×60), as they would have done, had no dislocation intervened. Some coal-fields, indeed, are so intersected with slips as to bewilder the most experienced miner, which will particularly happen when a lower coal is thrown upon one side of a slip, directly opposite to an upper coal situated on the other side of it; so that if the two seams be of the same thickness, erroneous conclusions are almost inevitable.

When a line of bores is to be conducted from the dip of the strata towards their outcrop, they should be placed a few yards nearer each other than the rule prescribes, lest the strata last passed through be overstepped, so that they may disappear from the register, and a valuable coal-seam may thereby escape notice. In fact, each successive bore should be so set down, that the first of the strata perforated should be the last passed through in the preceding bore; as is exemplified by viewing the bores in the retrograde direction, Nos. 4. 3. and 2. But if the bore No. 2. had gone no deeper than *f*, and the bore No. 1. been as represented, then the stratum *e*, with its immediately subjacent coal, would have been overstepped, since none of the bores would have touched it; and they would have remained unnoticed in the journal, and unknown.

When the line of dip, and consequently the line of bearing which is at right angles to it, are unknown, they are sought for by making three bores in the following position. —Let *fig.* 1078. be a horizontal diagram, in which the place of a bore, No. 1., is

shown, which reaches a coal-seam at the depth of 50 yards; bore No. 2. may be made at *a*, 300 yards from the former; and bore No. 3. at *c*, equidistant from Nos. 1. and 2.,



so that the bores are sunk at the three angles of an equilateral triangle. If the coal occur in No. 2. at the depth of 30 yards, and in No. 3. of 44 yards, it is manifest that none of the lines *a* *b*, *a* *c*, or *c* *a* is in the line of bearing, which for short distances may be taken for the line of bearing, with coal-seams of moderate dip. But since No. 1. is the deepest of the three bores, and No. 3. next in depth, the line *a* *c* joining them must be nearer the line of level, than either of the lines *a* *b* or *b* *c*. The question is, therefore, at what distance on the prolonged line *a* *c* is the point

for sinking a bore which would reach the coal at the same depth as No. 1., namely 50 yards. This problem is solved by the following rule of proportion: as 14 yards (the difference of depth between bores 2. and 3.) is to 300 yards (the distance between them), so is 20 (the difference of depth betwixt 1. and 2.) to a fourth proportion, or $x = 428$ yards, 1 foot, and 8 inches. Now, this distance, measured from No. 2., reaches to the point *n* on the prolonged line *a* *c*, under which point *n* the coal will be found at a depth of 50 yards, the same as under *a*. Hence the line *a* *n* is the true level line of the coal-field; and a line *b* *r* *g* drawn at right angles to it, is the true dip-line of the plane which leads to the outcrop. In the present example the dip is 1 yard in 14½; or 1 in 14½, to adopt the judicious language of the miner; or the sine is 1 to a radius of 14½, measured along the line from *a* to *r*. By this theorem for finding the lines of dip and level, the most eligible spot in a coal-field for sinking a shaft may be ascertained.

Suppose the distance from *a* to *c* in the line of dip to be 455 yards; then, since every 14½ gives a yard of depression, 455 will give 30 yards, which added to 30 yards, the depth of the bore at *a*, will make 60 yards for the depth of the same coal-seam at *c*. Since any line drawn at right angles to the line of level *a* *n* is the line of dip, so any line drawn parallel to *a* *n* is a level line. Hence, if from *c* the line *c* *x* be drawn parallel to *n* *a*, the coal-seam at the points *x* and *c* will be found in the same horizontal plane, or 44 yards beneath the surface level, over these two points. The point *x* level with *c* may also be found by this proportion: as 20 yards (the difference in depth of the bores under *a* and *a*) is to 300 yards (the distance between them), so is 14 yards (the difference of depth under *a* and *c*) to 210 yards, or the distance from *a* to *x*.

As boring for coal is necessarily carried on in a line perpendicular to the horizon, and as coal-seams lie at every angle of inclination to it, the thickness of the seam as given obliquely by the borer, is always greater than the direct thickness of the coal; and hence the length of that line must be multiplied by the cosine of the angle of dip, in order to find the true power of the seam.

Of fitting or winning a coal-field. — In sinking a shaft for working coal, the great obstacle to be encountered, is water, particularly in the first opening of a field, which proceeds from the surface of the adjacent country; for every coal-stratum, however deep it may lie in one part of the basin, always rises till it meets the alluvial cover, or crops out, unless it be met by a slip or dike. When the basset-edge of the strata is covered with gravel or sand, any body or stream of water will readily percolate downwards through it, and fill up the porous interstices between the coal-measures, till arrested by the face of a slip, which acts as a valve or flood-gate, and confines the water to one compartment of the basin, which may, however, be of considerable area, and require a great power of drainage.

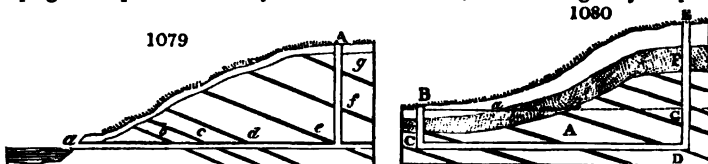
In reference to water, coal-fields are divided into two kinds; 1., level free coal; 2., coal not level free. In the practice of mining, if a coal-field, or portion of it, is so situated above the surface of the ocean that a level can be carried from that plane till it intersects the coal, all the coal above the plane of intersection is said to be level free; but if a coal-field, though placed above the surface of the ocean, cannot, on account of the expense, be drained by a level or gallery, but by mechanical power, such a coal-field is said to be not level free.

Besides these general levels of drainage, there are subsidiary levels, called off-takes or drifts, which discharge the water of a mine, not at the mouth of the pit, but at some depth beneath the surface, where, from the form of the country, it may be run off level free. From 20 to 30 fathoms off-take is an object of considerable economy in pumping; but even less is often had recourse to; and when judiciously contrived, may serve to intercept much of the crop water, and prevent it from getting down to the dip part of the coal, where it would become a heavy load on a hydraulic engine.

Day levels were an object of primary importance with the early miners, who had not the gigantic pumping power of the steam-engine at their command. Levels ought to be no less than 4 feet wide, and from 5 feet and a half to 6 feet high: which is large

enough for carrying off water, and admitting workmen to make repairs and clear out depositions. When a day-level, however, is to serve the double purpose of drainage and an outlet for coals, it should be nearly 5 feet wide, and have its bottom gutter covered over. In other instances a level not only carries off the water from the colliery, but is converted into a canal for bearing boats loaded with coals for the market. Some subterranean canals are nine feet wide, and twelve feet high, with 5 feet depth of water.

If in the progress of driving a level, workable coals are intersected before reaching the seam which is the main object of the mining adventure, an air-pit may be sunk, of such dimension as to serve for raising the coals. These air-pits do not in general exceed 7 feet in diameter; and they ought to be always cylindrical. Fig. 1079. represents a coal-field where the winning is made by a day-level; *a* is the mouth of the gallery on a level with the sea; *b*, *c*, *d*, *e*, are intersected coal-seams, to be drained by the gallery. But the coals beneath this level must obviously be drained by pumping. *A* represents a coal-pit sunk on the coal *e*; and if the gallery be pushed



forward, the coal-seams *f*, *g*, and any others which lie in that direction, will also be drained, and then worked by the pit *A*. The chief obstacle to the execution of day-levels, is presented by quicksands in the alluvial cover, near the entrance of the gallery. The best expedient to be adopted amid this difficulty is the following: — Fig. 1080. represents the strata of a coal-field *A*, with the alluvial earth *a*, *b*, containing the bed of quicksand *b*. The lower part, from which the gallery is required to be carried, is shown by the line *a d*. But the quicksand makes it impossible to push forward this day-level directly. The pit *a c* must therefore be sunk through the quicksand by means of *tubbing* (to be presently described), and when the pit has descended a few yards into the rock, the gallery or drift may then be pushed forward to the point *d*, when the shaft *x d* is put down, after it has been ascertained by boring that the rock-head or bottom of the quicksand at *r* is a few yards higher than the mouth of the small pit *a*. During this operation, all the water and mine-stuff are drawn off by the pit *a*; but whenever the shaft *x d* is brought into communication with the gallery, the water is allowed to fill it from *c* to *d*, and rise up both shafts till it overflows at the orifice *a*. From the surface of the water in the deep shaft at *c*, a gallery is begun of the common dimensions, and pushed onwards till the coal sought after is intersected. In this way no drainage level is lost. This kind of drainage gallery, in the form of an inverted siphon, is called a drowned or a blind level.

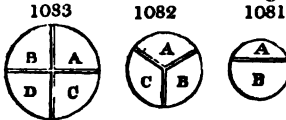
When a coal-basin is so situated that it cannot be rendered level free, the winning must be made by the aid of machinery. The engines at present employed in the drainage of coal-mines are: —

1. The water-wheel, and water-pressure engine.
2. The atmospheric steam-engine of Newcomen.
3. The steam-engine, both atmospheric and double stroke, of Watt.
4. The expansion steam-engine of Woolf.
5. The high-pressure steam-engine, without a condenser.

The depth at which the coal is to be won, or to be drained of moisture, regulates the power of the engine to be applied, taking into account the probable quantity of water which may be found, a circumstance which governs the diameter of the working barrels of the pumps. Experience has proved, that in opening collieries, even in new fields, the water may generally be drawn off by pumps of from 10 to 15 inches diameter; excepting where the strata are connected with rivers, sand-beds filled with water, or marsh-lands. As feeders of water from rivers or sand-beds may be hindered from descending coal-pits, the growth proceeding from these sources need not be taken into account; and it is observed, in sinking shafts, that though the influx which cannot be cut off from the mine, may be at first very great, even beyond the power of the engine for a little while, yet as this excessive flow of water is frequently derived from the drainage of fissures, it eventually becomes manageable. An engine working the pumps for 8 or 10 hours out of the 24, is reckoned adequate to the winning of a new colliery, which reaps no advantage from neighbouring hydraulic powers. In the course of years, however, many water-logged fissures come to be cut by the workings, and the coal seams get excavated towards the outcrop, so that a constant increase of water ensues, and thus a colliery which has been long in operation, frequently becomes heavily

loaded with water, and requires the action of its hydraulic machinery both night and day.

Of Engine Pits. — In every winning of coal, the shape of the engine-pit deserves much consideration. For shafts of moderate depth, many forms are in use; as circular, oval, square, octagonal, oblong rectangular, and oblong elliptical. In pits of inconsiderable depth, and where the earthy cover is firm and dry, any shape deemed most convenient may be preferred; but in all deep shafts, no shape but the circular should be admitted. Indeed, when a water-run requires to be stopped by tubbing or cribbing, the circular is the only shape which presents a uniform resistance in every point to the equable circumambient pressure. The elliptical form is the next best, when it deviates little from the circle; but even it has almost always given way to a considerable pressure of water. The circular shape has the advantage, moreover, of strengthening the shaft walls, and is less likely to suffer injury than other figures, should any failure of the pillars left in working out the coal cause the shaft to be shaken by subsidence of the strata. The smallest engine-pit should be ten feet in diameter, to admit of the pumps being placed in the lesser segment, and the coals to be raised in the larger one, as shown in *fig. 1801.*, which is called a double pit. If much work is contemplated in drawing coals, particularly if their masses be large, it would be advantageous to make the pit more than 10 feet wide.



When the area of a shaft is to be divided into three compartments, one for the engine pumps, and two for raising coals, as in *fig. 1082.*, which is denominated a triple pit, it should be 12 feet in diameter. If it is to be divided into four compartments, and made a quadrant shaft, as in *fig. 1083.*, with one space for the pumps, and three for ventilation and coal-drawing, the total circle should be 15 feet in diameter. These dimensions are, however, governed by local circumstances, and by the proposed daily discharge of coals.

The shaft, as it passes through the earthy cover, should be securely faced with masonry of jointed ashlar, having its joints accurately bevelled to the centre of the circle. Specific directions for building the successive masses of masonry, on a series of rings or cribs of oak or elm, are given by Mr. Bald, article *MINE*, *Brewster's Encyclopedia*, p. 336.

When the alluvial cover is a soft mud, recourse must be had to the operation of tubbing. A circular tub, of the requisite diameter, is made of planks from 2 to 3 inches thick, with the joints bevelled by the radius of the shaft, inside of which are cribs of hard wood, placed from 2 to 4 feet asunder, as circumstances may require. These cribs are constructed of the best heart of oak, sawn out of the natural curvature of the wood, adapted to the radius, in segments from 4 to 6 feet long, from 8 to 10 inches in the bed, and 5 or 6 inches thick. The length of the tub is from 9 to 12 feet, if the layer of mud have that thickness; but a succession of such tubs must be set on each other, provided the body of mud be thicker. The first tub must have its lower edge thinned all round, and shod with sharp iron. If the pit be previously secured to a certain depth, the tub is made to pass within the cradling, and is lowered down with tackles till it rests fair among the soft alluvium. It is then loaded with iron weights at top, to cause it to sink down progressively as the mud is removed from its interior. Should a single tub not reach the solid rock (sandstone or basalt), then another of like construction is set on, and the gravitating force is transferred to the top. *Fig. 1084.* represents a bed of quicksand resting on a bed of impervious clay, that immediately covers the rock. *A* is the finished shaft; *a a*, the quicksand; *b b*, the excavation necessarily sloping much outwards; *c*, the lining of masonry; *d d*, the moating or puddle of clay, hard rammed in behind the stone-work,

to render the latter water-tight. In this case, the quicksand, being thin in body, has been kept under for a short period, by the hands of many men scooping it rapidly away as it filled in. But the most effectual method of passing through beds of quicksand, is by means of cast-iron cylinders; called, therefore, cast-iron tubbing. When the pit has a small diameter, these tubs are made about 4 feet high, with strong flanges, and bolt holes inside of the cylinder, and a counterfort ring at the neck of the flange, with brackets: the first tub, however, has no flange at its lower edge, but is rounded to facilitate its descent through the mud. Should the pit be of large diameter, then the cylinders must be cast in segments of 3, 4, or more pieces, joined together with inside vertical flanges, well jointed with oakum and white lead. When the sand-bed is thick, eighty feet, for instance, it is customary to divide that length into three sets of cylinders, each thirty feet long, and so sized as to slide within each other, like the eye tubes of a telescope. These cylinders are pressed down by heavy weights, taking care to

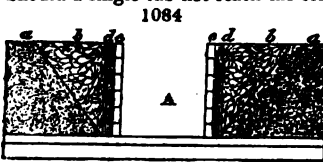


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keep the lower part always further down than the top of the quicksand, where the men are at work with their shovels, and where the bottom of the pumps hangs for withdrawing the surface water. This is an improvement adopted of late years in the Newcastle district with remarkable success.

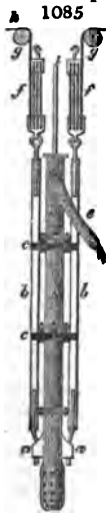
The engine pit being secured, the process of sinking through the rock is ready to be commenced, as soon as the divisions of the pit formed of carpentry, called brattices, are made. In common practice, and where great tightness of jointing is not required, for ventilating inflammable air, bars of wood, called buntuns, about 6 inches thick, and 9 deep, are fixed in a horizontal position across the pit, at distances from each other of 10, 20, or 30 feet, according to circumstances. Being all ranged in the same vertical plane, deals an inch and a half thick are nailed to them, with their joints perfectly close; one half of the breadth of a buntun being covered by the ends of the deals. In deep pits, where the ventilation is to be conducted through the brattice, the side of the buntuns next the pumps is covered with deals in the same way, and the joints are rendered secure by being caulked with oakum. Fillets of wood are also fixed all the way down on each side of the brattice, constituting what is called a double pit.

When a shaft is to have 3 compartments, it requires more care to form the brattice, as none of the buntuns stretch across the whole space, but merely meet near the middle, and join at certain angles with each other. As the buntuns must therefore sustain each other, on the principle of the arch, they are not laid in a horizontal plane, but have a rise from the sides towards the place of junction of 8 or 9 inches, and are bound together by a three-tongued iron strap. Fillets of wood are carried down the whole depth, not merely at the joinings of the brattice with the sides of the pit, but also at their central place of union; while wooden pillars connect the centre of each set of buntuns with those above and below. Thus the carpentry work acquires sufficient strength and stiffness.

In quadrant shafts the buntuns cross each other towards the middle of the pit, and are generally let into each other about an inch, instead of being half-checked. *Fig. 1081.* is a double shaft: *a*, the pump pit; *b*, the pit for raising coal. *Fig. 1082.* is a triple shaft; in which *a* is the pump compartment; *b* and *c* are coal pits. *Fig. 1083.* is a quadrant shaft: *a*, the pump pit; *b*, pit of ventilation or upcast for the smoke; *c* and *d*, pits for raising coals.

A depth of 75 fathoms is fully the average of engine pits in Great Britain. In practice, it embraces three sets of pumps. Whenever the shaft is sunk so low that the engine is needed to remove the water, the first set of pumps may be let down by the method represented in *fig. 1085.*; where *a* is the pump; *a a*, strong ears through which pass the iron rods connected with the spears *b b*; *c c* are the lashings; *d*, the hoggar pump; *e*, the hoggar; *f f*, the tackles; *g g*, the single pulleys; *h h*, the tackle fold leading to the capstans; and *i*, the pump-spears. By this mechanical arrangement the pumps are sunk in the most gradual manner, and of their own accord, so to speak, as the pit descends. To the arms of the capstans, sledges are fastened with ropes or chains; these sledges are loaded with weights, as counterpoises to the weight of the column of pumps, and when additional pumps are joined in, more weight is laid on the sledges. As the sinking set of pumps is constantly descending, and the point for the delivery of the water above always varying, a pipe of equal diameter with the pumps, and about 11 feet long, but much lighter in the metal, is attached to *e*, and is terminated by a hose of leather, of sufficient length to reach the cistern where the water is delivered. This is called the hoggar-pipe. In sinking, a vast quantity of air enters with the water, at every stroke of the engine; and therefore the lifting stroke should be very slow, and a momentary stop should take place before the returning stroke, to suffer all the air to escape. As the working barrels are generally 9 or 10 feet long, and the full stroke of the engine from 7 to 8 feet, when at regular work, it is customary to diminish the length of stroke, in sinking, to about 6 feet; because, while the pumps are constantly getting lower, the bucket in the working barrel has its working range progressively higher.

The usual length for a set of pumps, is from 25 to 30 fathoms. Whenever this depth is arrived at by the first set, preparations are made for fixing firmly the upper pit-cistern, into which the upper set of pumps is to be placed, and the water of the second set is to be thrown. If a strong bed of sandstone occurs, a scarcement of it is left projecting about 3 feet into the shaft, which is formed in the course of sinking into a strong chin or bracket, to sustain that part of the cistern in which the superior set of pumps stands. A few feet beneath this scarcement the shaft resumes its usual shape.



But although from 20 to 30 fathoms be the common length of a pump-lift, it sometimes becomes necessary to make it much longer, when no place can be found in the

1086 shaft for lodging a cistern, on account of the tubing. Hence a pump-lift has been occasionally extended to 70 fathoms; which requires extraordinary strength of materials. The best plan for collaring the pumps in the pit, and keeping them steady in a perpendicular line, is to fix a strong buntun of timber under the joints of each pipe; and to attach the pipes firmly to these buntuns by an iron collar, with screws and nuts, as represented in *fig. 1086*.

The water obtained in sinking through the successive strata is, in ordinary cases, conducted down the walls of the shaft; and if the strata are compact, a spiral groove is cut down the sides of the shaft, and when it can hold no more, the water is drawn off in a spout to the nearest pump-cistern; or a perpendicular groove is cut in the side of the shaft, and a square box-pipe either sunk in it, flush with the sides of the pit, or it is covered with deal boards well fitted over the cavity. Similar spiral rings are formed in succession downwards, which collect the trickling streams, and conduct them into the nearest cistern; or rings, made of wood or cast iron, are inserted flush with the sides of the pipe; and the water is led from one ring to another, through perpendicular pipes, until the undermost ring is full, when it delivers its water into the nearest pump-cistern. Keeping the shaft dry is very important to the comfort of the miners, and the durability of the work.

When an engine shaft happens to pass through a great many beds of coal, a gallery a few yards long is driven into each coal-seam, and a bore then put down from one coal to another, so that the water of each may pass down through these bores to the pump-cisterns.

While a deep pit is sinking, a register is kept of every part of the excavations, and each feeder of water is measured daily, to ascertain its rate of discharge, and whether it increases or abates. The mode of measurement, is by noting the time, with a seconds watch, in which a cistern of 40 or 50 gallons gets filled. There are three modes of keeping back or stopping up these feeders; by plank tubing; iron tubing; and by oak cribs. Let *fig. 1087*, represent the sinking of a shaft through a variety of strata,



having a top cover of sand, with much water resting on the rock summit. Each plane of the coal-measure rises in a certain direction till it meets the alluvial cover. Hence, the pressure of the water at the bottom of the tubing that rests on the summit of the rock, is as the depth of water in the superficial alluvium; and if a stratum *a* affords a great body of water, while the superjacent stratum *b*, and the subjacent *c*, are impervious to water; if the porous bed *a* be 12 feet thick, while no water occurs in the strata passed through from the rock head, until that depth (supposed to be 50 fathoms from the surface of the water in the cover); in this case, the tubing or cribbing must sustain the sum of the two water pressures, or 62 fathoms; since the stratum *a* meets the alluvial cover at *d*, the fountain head of all the water that occurs in sinking. Thus we perceive, that though no water-feeder of any magnitude should present itself till the shaft had been sunk 100 fathoms; if this water required to be stopped up or tubbed off through the breadth of a stratum only 3 feet thick, the tubing floodgate would need to have a strength to resist 100 fathoms of water-pressure. For though the water at first oozes merely in discontinuous particles through the open pores of the sands and sandstones, yet it soon fills them up, like a myriad of tubes, which transfer to the bottom the total weight of the hydrostatic column of 100 fathoms; and experience shows, as we have already stated, that whatever water occurs in coal-pits or in mines, generally speaking, proceeds from the surface of the ground. Hence, if the cover be an impervious bed of clay, very little water will be met with among the strata, in comparison of what would be found under sand.

When several fathoms of the strata must be tubbed, in order to stop up the water-flow, the shaft must be widened regularly to admit the kind of tubing that is to be inserted; the greatest width being needed for plank-tubbing, and the least for iron-tubbing. *Fig. 1088*, represents a shaft excavated for plank-tubbing, where *a, a* are the

1088 impervious strata, *b, b* the porous beds water-logged, and *c, c* the bottom of the excavation, made level and perfectly smooth with mason-chisels. The same precautions are taken in working off the upper part of the excavation *d, d*. In this operation, three kinds of cribs are employed; called wedging, spiking, and main cribs. Besides the stout plank for making the tub, a quantity of well-seasoned and clean reeded deal is required for forming the joints; called sheeting deal by the workmen.

This sheeting deal is always applied in pieces laid endwise, with the end of the fibres towards the area of the pit. Since much of the security from water depends on the

tightness of the tub at its jointing with the rock, several plans have been contrived to effect this object; the most approved being represented in *Fig. 1089*. To make room 1089 for the lower wedging crib, the recess is excavated a few inches wider, as at *c*; and from *b* to *c*, sheeting deals are laid all round the circle, or a thin stratum of oakum is introduced. On this the wedging crib *d* is applied, and neatly jointed in the radius-line of the pit, each segment being drawn exactly to the circle: and at each of its segments sheeting deal is inserted. This wedging crib must be 10 inches in the bed, and 6 inches deep. The vacuity *e*, at the back of the crib, about 2 and a half inches wide, is filled with pieces of dry clean reeded deal, inserted endwise; which is regularly wedged with one set of wedges all round, and then with a second and a third set of wedges, in the same regular style, to keep the crib in a truly circular posture. By this process, well executed, no water can pass downwards by the back of the crib. The next operation is to fix spiking cribs *f*, to the rock, about 10 or 12 feet from the lower crib, according to the length of the planks to be used for the tubs. They must be set fair to the sweep of the shaft, as on them its true circular figure depends. The tubbing deals *k*, must now be fixed. They are 3 inches thick, 6 broad, and planed on all sides, with the joints accurately worked to the proper bevel for the circle of the pit. The main cribs *g, g*, are then to be placed as counterforts, for the support and strength of the tubbing. The upper ends of the first set of tub-planks being cut square and level all round, the second spiking crib *l*, is fixed, and another set of tubbing deals put round like the former, having sheeting deal inserted betwixt the ends of the two sets at *f*. When this is wedged, the cribs *h, h*, are placed.

Oak cribbing is made with pieces of the best oak, from 3 to 4 feet long, 10 inches in the bed, and 7 or 8 inches deep.

The third mode of tubbing, by means of iron cylinders cast in segments, is likely henceforth to supersede the wooden tubbing, from the great reduction in the price of iron, and its superior strength and durability. Each segment is adjusted piece to piece in the circular recess of the pit cut out for their reception. The flange for the wedging joint is best turned inwards. In late improvements of this plan, executed by Mr. Buddle, where the pressure amounted to several hundred feet, the segments were 6 feet long, 2 feet broad, and an inch thick, counterforted with ribs or raised work on the back; the lip of the flange was strong, and supported by brackets. These segments of the iron cylinder are set true to the radius of the pit; and every horizontal and perpendicular joint is made tight with a layer of sheeting deal. A wedging crib is fixed at the bottom, and the segments are built up regularly with joints like ashler-work. This kind of tubbing can be carried to any height, till the water finds an outlet at the surface, or till strata containing water can be tubbed off, as by the modes of tubbing already described. A shaft finished in this manner presents a smooth lining-wall of iron, the flanges being turned towards the outside of the cylinders. In this iron tubbing, no screw bolts are needed for joining the segments together; as they are packed hard within the pit, like the staves of a cask. There is a shaft in the Newcastle district, where 70 fathoms have been executed in this way, under the direction of Mr. Buddle.

When a porous thin bed or parting betwixt two impervious strata, gives out much water, or when the fissures of the strata, called cutters, are very leaky, the water can be completely stopped up by the improved process of wedging. The fissure is cut open with chisels, to a width of two, and a depth of seven inches, as represented in *Fig. 1090*. The lips being rounded off about an inch and a half, pieces of clean deal are then driven in, whose face projects no further than the contour of the lips; when the whole is firmly wedged, till the water is entirely stopped. By sloping back the edges of the fissures, and wedging back from the face of the stone, it is not liable to burst or crack off in the operation, as took place in the old way, of driving in the wedge directly.

Ventilation of Engine Pits.—In ordinary cases, while the sinking of the shaft is going on, the brattice walls produce a circulation, in consequence of the air being slightly lighter in one compartment than in another. If this does not occur, the circulation of air must be produced by artificial means. The most approved contrivance is, to cover the engine compartment of the shaft with deals, leaving apertures for the pump-spears and tackling to pass through, with hatch-doors for the men, and to carry a brick flue at least 3 feet square, in a horizontal direction, from the mouth of that compartment to an adjoining high chimney connected with a furnace, as represented *Fig. 1091*. *a, a*, are double doors, for the fireman to supply fuel by; *b*, the mouth of the horizontal flue; *c*, the furnace; *d*, the ash-pit; *e*, the furnace; *f*, the upright chimney for draught, from 50 to 100 feet high, from 8 to 10 feet square at bottom, and tapering upwards to 3 or 4 feet



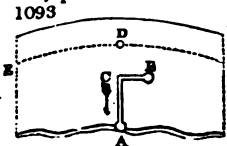
square inside. Such a furnace and chimney are also needed for ventilating the coal-mine through all its underground workings. When a great quantity of gas issues from one place in a pit, it is proper to carry it up in a square wooden pipe, which terminating at some distance above the surface in a helmet-shaped funnel, fitted to turn like a vane, may cause considerable ventilation of itself; or the top of such a pipe may be connected with a small fireplace, which will cause a rapid current up through it, from the pit. The stones and rubbish produced in sinking, are drawn up with horse-gins, when the pit is not deep; but in all shafts of considerable depth, a steam engine is used, and the workmen have now more confidence in them, as to personal safety, than in machines impelled by horses.

The great collieries of Newcastle are frequently worked by means of one shaft divided into compartments, which serves as an engine-pit, and coal-pits, and by these the whole ventilation is carried on to an extent and through ramifications altogether astonishing. This system has been adopted on account of the vast expense of a large shaft, often amounting to 60,000*l.* or 80,000*l.*, including the machinery. The British collieries, however, are in general worked by means of an engine-pit, and a series of other pits, sunk at proper distances for the wants of the colliery.

WORKING OF COAL.

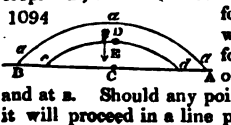
A stratum, bed, or seam of coal, is not a solid mass, of uniform texture, nor always of homogeneous quality in burning. It is often divided and intersected, with its concomitant strata, by what are named partings, backs, cutters, reeds, or ends. Besides the chief partings at the roof and pavement of the coal seam, there are subordinate lines of parting in the coal mass, parallel to these of variable dimensions. These divisions are delineated in *fig. 1092.*, where $\Delta, B, C, D, E, F, G, H,$ represent a portion of a bed of coal, the parallelogram $\Delta B D C$ the parting at the roof, and $E F G$ the parting at the pavement; $a b, b c, d e,$ and $e f,$ are the subordinate or intermediate partings; $g h, i k, l m,$ the backs; $o p, p q, r s, s t, u v,$ and $v w,$ the cutters. It is thus manifest that a bed of coal, according to the number of these natural divisions, is subdivided into solid figures of various dimensions, and of a cubical or rhomboidal shape.

When the engine-pit is sunk, and the lodgement formed, a mine is then run in the coal to the rise of the field, or a cropping from the engine-pit to the second pit. This mine may be 6 or 8 feet wide, and carried either in a line directly to the pit bottom, or at right angles to the backs or web of the coal, until it is on a line with the pit, where a mine is set off, upon one side, to the pit bottom. This mine or gallery is carried as nearly parallel to the backs as possible, till the pit is gained. *Fig. 1093.* represents this mining operation. Δ is the engine-pit, B , the second or bye-pit. ΔC , the gallery driven at right angles to the backs. $C B$, the gallery set off to the left hand, parallel to the backs. The next step is to drive the drip-head or main-levels from the engine-pit bottom, or from the dip-head of the backset immediately contiguous to the engine-pit bottom. In this business, the best colliers are always employed, as the object



is to drive the gallery in a truly level direction, independently of all sinkings or risings of the pavement. For coal seams of ordinary thickness, this gallery is usually not more than 6 feet wide; observing to have on the dip side of the gallery a small quantity of water, like that of a gutter, so that it shall always be about 4 or 6 inches deep at the forehead upon the dip-wall. When the level is driven correctly, with the proper depth of water, it is said to have dead water at the forehead. In this operation, therefore, the miner pays no regard to the backs or cutters of the coal; but is guided in his line of direction entirely by the water-level, which he must attend to solely, without regard to slips or dislocations of the strata throwing the coal up or down. In the last figure, the coal-field is a portion of a basin; so that if the shape be uniform and unbroken, and if any point be assumed a dipping from the crop, as $\Delta, D, E, F,$ and the levels from any point whatever a-dipping, will be also parallel to these; and hence, were the coal-field an entire elliptical basin, the dip-head levels carried from any point would be elliptical, and parallel to the crop. If, as is more commonly the case, the coal-field be merely a portion of a basin,

formed by a slip of the strata, as represented in *fig. 1094.*, where $a, a, a,$ is the crop, and $\Delta, B,$ a slip of great magnitude, forming another coal-field on the side c , then the crop not only meets the alluvial cover, but is cut off by the slip at Δ and at a . Should any point, therefore, be assigned for an engine-pit, the levels from it will proceed in a line parallel to the crop, as $d, d, d,$ and the level on both sides of



the engine-pit will be also cut off by the alip *a a*. In this figure, the part included between the two curve lines, is the breadth or breast of coal-field won by the engine-pit *b*; what is not included, is termed the under-dip coal, and can be worked only by one or more new winnings towards the dip, according to circumstances.

In British practice, there are four different systems of working coal-mines:—

1. Working with pillars and rooms, styled post and stall, where the pillars left, bear such proportion to the coal excavated, as is just adequate to the support of the incumbent strata.

2. Working with post and stall, where the pillars are left of an extra size, and stronger than may be requisite for bearing the superior strata, with the intention of removing a considerable portion of each massive pillar, whenever the regular working of post and stall has been finished in the colliery.

3. Working with post and stall, or with comparatively narrow rooms or boards, whereby an uncommonly large proportion of coal is left, with the view of working back towards the pits, whenever the colliery is worked in this manner to the extent of the coal-field, and then taking away every pillar completely, if possible, and allowing the whole superincumbent strata to crush down, and follow the miners in their retreat.

4. Working the long way, being the Shropshire method; which leaves no pillars, but takes out all the coal progressively as the workings advance. On this plan, the incumbent strata crush down, creeping very close to the heads of the miners.

The post and stall system is practised with coals of every thickness. The Shropshire method is adopted generally with thin coals; for when the thickness exceeds 6 or 7 feet, this mode has been found impracticable.

The following considerations must be had in view in establishing a coal-mine:—

1. The lowest coal of the winning should be worked in such a manner as not to injure the working or the value of the upper coals of the field; but if this cannot be done, the upper coals should be worked in the first place.

2. The coals must be examined as to texture, hardness, softness, the number and openness of the backs and cutters.

3. The nature of the pavement of the coal seam, particularly as to hardness and softness; and if soft, to what depth it may be so.

4. The nature of the roof of the coal-seam, whether compact, firm, and strong; or weak and liable to fall; as also the nature of the superincumbent strata.

5. The nature of the alluvial cover of the ground, as to water, quicksands, &c.

6. The situation of rivers, lakes, or marshes, particularly if any be near the outcrop of the coal strata.

7. The situation of towns, villages, and mansion-houses, upon a coal-field, as to the chance of their being injured by any particular mode of mining the coal.

Mr. Bald gives the following general rules for determining the best mode of working coal:—

"1. If the coal, pavement, and roof are of ordinary hardness, the pillars and rooms may be proportioned to each other, corresponding to the depth of the superincumbent strata, providing all the coal proposed to be wrought is taken away by the first working, as in the first system; but if the pillars are to be winged afterwards, they must be left of an extra strength, as in the second system.

"2. If the pavement is soft, and the coal and roof strong, pillars of an extra size must be left, to prevent the pillars sinking into the pavement, and producing a creep.

"3. If the coal is very soft, or has numerous open backs and cutters, the pillars must be left of an extra size, otherwise the pressure of the superincumbent strata will make the pillars fly or break off at the backs and cutters, the result of which would be a total destruction of the pillars, termed a crush or sit, in which the roof sinks to the pavement, and closes up the work.

"4. If the roof is very bad, and of a soft texture, pillars of an extra size are required, and the rooms or boards comparatively very narrow.

"In short, keeping in view all the circumstances, it may be stated generally, that when the coal, pavement, and roof are good, any of the systems before mentioned may be pursued in the working; but if they are soft, the plan is to work with rooms of a moderate width, and with pillars of great extra strength, by which the greater part of the coal may be got out at the last of the work, when the miners retreat to the pit bottom, and there finish the workings of a pit."

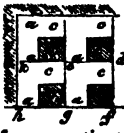
Fig. 1095 represents the effects of pillars sinking into the pavement, and producing a creep; and *fig. 1096* exhibits large pillars and a room, with the roof stratum bending down before it falls at *a*. Thus the roads will be shut up, the air-courses destroyed, and the whole economy of the mining operations deranged.

The proportion of coal worked out, to that left in the pillars, when all the coal intended to be removed is taken out at the first working, varies from



four-fifths to two-thirds; but as the loss of even one-third of the whole area of coal is far too much, the better mode of working suggested in the third system ought to be adopted.

The proportion of a winning to be worked may be thus calculated. Let *fig. 1097*, be a small portion of the pillars, rooms, and thirlings formed in a coal-field;



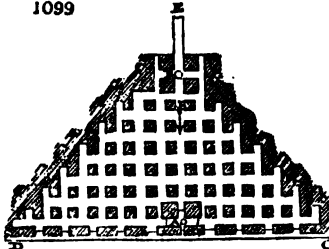
Suppose the rooms to be 12 feet wide, the thirlings to be the same, and the pillars 12 feet on each side; adding the face of the pillar to the width of the room, the sum is 24; and also the end of the pillar to the width of the thirling, the sum is likewise 24: then $24 \times 24 = 576$; and the area of the pillar is $12 \times 12 = 144$; and as 576 divided by 144, gives 4 for a quotient, the result is, that one fourth of the coal is left in pillars, and three fourths extracted. Let *d, e, f, g*, be one winning, and *g, e, h, a*, another. By inspecting the figure, we perceive the workings of a coal-field are resolved into quadrangular areas, having a pillar situated in one of the angles.

In forming the pillars and carrying forwards the boards with regularity, especially where the backs and cutters are very distinct and numerous, it is of importance to work the rooms at right angles to the backs, and the thirlings in the direction of the cutters, however oblique these may be to the backs, as the rooms are by this means conducted with the greatest regularity with regard to each other, kept equidistant, and the pillars are strongest under a given area. At the same time, however, it seldom happens that a back or cutter occurs exactly at the place where a pillar is formed; but this is of no consequence, as the shearing or cutting made by the miner ought to be in a line parallel to the backs and cutters. It frequently happens that the dip-head level intersects the cutters in its progress at a very oblique angle. In this case, when rooms and pillars are set off, the face of the pillar and width of the room must be measured off an extra breadth in proportion to the obliquity, as in *fig. 1098*. By neglect of this rule, much confusion and irregular work is often produced. It is, moreover, proper to make the first set of pillars next the dip-head level much stronger, even where there is no obliquity, in order to protect that level from being injured by any accidental crush of the strata.



We shall now explain the different systems of working: one of the simplest of which is shown in *fig. 1099*; where *a* represents the engine-pit, *b* the bye-pit, *c* *n* the dip-head

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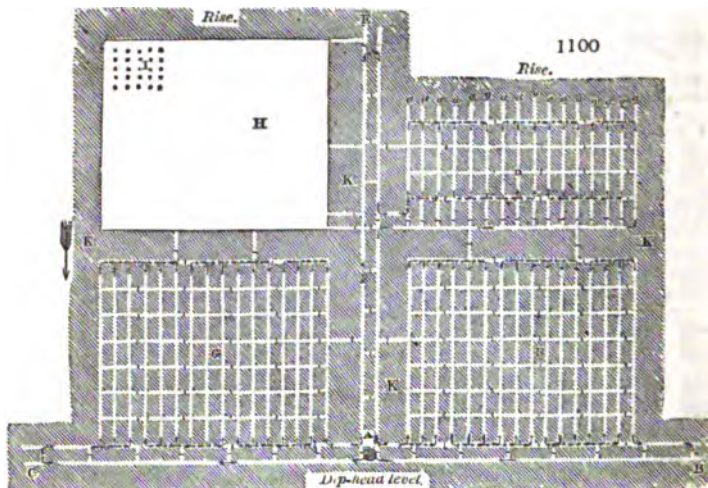


levels, always carried in advance of the rooms, and *x* the rise or crop gallery, also carried in advance. These galleries not only open out the work for the miners in the coal-bed, but, being in advance, afford sufficient time for any requisite operation, should the mines be obstructed by dikes or hitches. In the example before us, the rooms or boards are worked from the dip to the crop; the leading rooms, or those most in advance, are on each side of the crop gallery *x*; all the other rooms follow in succession, as shown in the figure; consequently, as the rooms advance to the crop, additional rooms are begun at the dip-head level, towards *c* and *n*. Should the coal work better in a level-course direction, then the level rooms are next the dip-head level, and the other rooms follow in succession. Hence the rooms are carried a cropping in the one case, till the coal is cropped out, or is no longer workable; and in the other, they are extended as far as the extremity of the dip-head level, which is finally cut off, either by a dike or slip, or by the boundary of the coal-field.

When the workings are so very deep as from 100 to 200 fathoms, the first workings are carried forward with rooms, pillars, and thirlings, but under a different arrangement, on account of the great depth of the superincumbent strata, the enormous expense incident to sinking a pit, and the order and severity of discipline indispensable to the due ventilation of the mines, the preservation of the workmen, and the prosperity of the whole establishment. To the celebrated Mr. Buddle the British nation is under the greatest obligations for devising a new system of working coal-mines, whereby nearly one-third of the coals has been rescued from waste and permanent destruction. This system is named panel work; because, instead of carrying on the coal-field winning in one extended area of rooms and pillars, it is divided into quadrangular panels, each panel containing an area of from 8 to 12 acres; and round each panel is left at first a solid wall of coal from 40 to 50 yards thick. Through the panel walls roads and air-courses are driven, in order to work the coal contained within these walls. Thus all the panels are connected together with the shaft, as to roads and ventilation. Each district or

panel has a particular name; so that any circumstance relative to the details of the colliery, casualties as to falls and crushes, ventilation, and the safety of the workmen, can be referred to a specific place.

Fig. 1100. represents a part of a colliery laid out in four panels, according to the improved method. To render it as distinct as possible, the line of the boards is at right



angles with the dip-head level, or level course of the coal. Δ is the engine-shaft, divided into three compartments, an engine-pit and two coal-pits, like *fig. 1082*. One of the coal-pits is the down-cast, by which the atmospheric air is drawn down to ventilate the works; the other coal-pit is the up-cast shaft, at whose bottom the furnace for rarefying the air is placed. Δc , is the dip-head level; Δx , the rise or crop gallery; x, x , the panel walls; r, a , are two panels completed as to the first work; n , is a panel, with the rooms a, a, a , in regular progress to the rise; h , is a panel fully worked out, whence nearly all the coal has been extracted; the loss amounting in general to no more than a tenth, instead of a third, or even a half, by the old method. By this plan of Mr. Buddle's, also, the pillars of a panel may be worked out at any time most suitable for the economy of the mining operation; whereas formerly, though the size of the pillars and general arrangement of the mine were made with the view of taking out ultimately a great proportion of the pillars, yet it frequently happened that, before the workings were pushed to the proposed extent, some part of the mine gave way, and produced a crush; but the most common misfortune was the pillars sinking into the pavement, and deranging the whole economy of the field. Indeed the crush or creep often overran the whole of the pillars, and was resisted only by the entire body of coal at the wall faces; so that the ventilation was entirely destroyed, the roads leading from the wall faces to the pit-bottom shut up and rendered useless, and the recovery of the colliery by means of new air-courses, new roads, and by opening up the wall faces or rooms, was attended with prodigious expense and danger. Even when the pillars stood well, the old method was attended with other very great inconveniences. If water broke out in any particular spot of the colliery, it was quite impossible to arrest its progress to the engine-pit; and if the ventilation was thereby obstructed, no idea could be formed where the cause might be found, there being instances of no less than 30 miles of air-courses in one colliery. And if from obstructed ventilation an explosion of the fire-damp occurred while many workmen were occupied along the extended wall faces, it was not possible to determine where the disaster had taken place; nor could the viewiers and managers know where to bring relief to the forlorn and mutilated survivors.

In Mr. Buddle's system all these evils are guarded against, as far as human science and foresight can go. He makes the pillars very large, and the rooms or boards narrow; the pillars being in general 12 yards broad, and 24 yards long; the boards 4 yards wide, and the walls or thirlings cut through the pillars from one board to another, only 5 feet wide, for the purpose of ventilation. In the figure, the rooms are represented as proceeding from the dip to the crop, and the panel walls act as barriers thrown round the area of the panel, to prevent the weight of the superincumbent strata from over-running the adjoining panels. Again, when the pillars of a panel are to be worked, one range of pillars, as at 1 (in h), is first attacked; and as the workmen cut away the furthest

pillars, columns of prop-wood are erected betwixt the pavement and the roof, within a few feet of each other (as shown by the dots), till an area of above 100 square yards is cleared of pillars, presenting a body of strata perhaps 130 fathoms thick, suspended clear and without support, except at the line of the surrounding pillars. This operation is termed working the *goaff*. The only use of the prop-wood is to prevent the seam, which forms the ceiling over the workmen's heads, from falling down and killing them by its splintery fragments. Experience has proved, that before proceeding to take away another set of pillars, it is necessary to allow the last-made goaff to fall. The workmen then begin to draw out the props, which is a most hazardous employment. They begin at the more remote props, and knock them down one after another, retreating quickly under the protection of the remaining props. Meanwhile the roof-stratum begins to break by the sides of the pillars, and falls down in immense pieces; while the workmen still persevere, boldly drawing and retreating till every prop is removed. Nay, should any props be so firmly fixed by the top pressure, that they will not give way to the blows of heavy mauls, they are cut through with axes; the workmen making a point of honour to leave not a single prop in the goaff. The miners next proceed to cut away the pillars nearest to the sides of the goaff, setting prop-wood, then drawing it, and retiring as before, until every panel is removed, excepting small portions of pillars which require to be left under dangerous stones to protect the retreat of the workmen. While this operation is going forward, and the goaff extending, the superincumbent strata being exposed without support over a large area, break progressively higher up; and when strong beds of sandstone are thus giving way, the noise of the rending rocks is very peculiar and terrific; at one time loud and sharp, at another hollow and deep.

As the pillars of the panels are taken away, the panel walls are also worked progressively backwards to the pit bottom; so that only a very small proportion of coal is eventually lost. This method is undoubtedly the best for working such coals as those of Newcastle, considering their great depth beneath the surface, their comparative softness, and the profusion of inflammable air. It is evident that the larger the pillars and panel walls are, in the first working, the greater will be the security of the miners, and the greater the certainty of taking out, in the second stage, the largest proportion of coal. This system may be applied to many of the British collieries; and it will produce a vast quantity of coals beyond the post and stall methods, so generally persisted in.

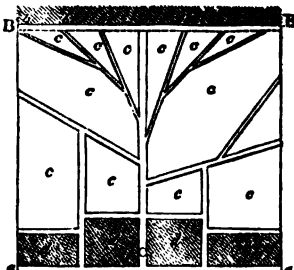
In thus tearing to pieces the massive rocks over his head, the miner displays a determined and cool intrepidity; but his ingenuity is no less to be admired in contriving modes of carrying currents of pure atmospheric air through every turning of his gloomy labyrinth, so as to sweep away the explosive spirit of the mine.

The fourth system of working coal, is called the *long way*, the long-wall, and the Shropshire method. The plan must at first have been extremely hazardous; though now it is so improved as to be reckoned as safe, if not safer, to the workmen, than the other methods, with rooms and pillars.

The object of the Shropshire system, is to begin at the pit-bottom pillars, and to cut away at once every inch of coal progressively forward, and to allow the whole superincumbent strata to crush down behind and over the heads of the workmen. This plan is pursued chiefly with coals that are thin, and is very seldom adopted when the seam is 7 feet thick; from 4 to 5 feet being reckoned the most favourable thickness for proceeding with comfort, amidst ordinary circumstances, as to roof, pavement, &c. When a pit is opened on a coal to be treated by this method, the position of the coals above the lowest seam sunk to, must first be considered; if the coal beds be contiguous, it will be proper to work the upper one first, and the rest in succession downwards; but if they are 8 fathoms or more apart, with strata of strong texture betwixt them, the working of the lower coals in the first place will do no injury to that of the upper coals, except breaking them, perhaps, a little. In many instances, indeed, by this operation on a lower coal, upper coals are rendered more easily worked.

When the operation is commenced by working on the Shropshire plan, the dip-head levels are driven in the usual manner, and very large bottom pillars are formed, as represented in *fig. 1101*. Along the rise side of the dip-head level, chains of wall, or long pillars, are also made, from 8 to 10 yards in breadth, and only mined through occasionally, for the sake of ventilation, or of forming new roads. In other cases no pillars are left upon the rise side of the level; but, instead of them, buildings of stone are reared, 4 feet broad at the base, and 9 or 10 feet from the dip side of the level. Though the roads are made 9 feet wide at first, they are reduced to half that width after the full pressure of the strata is upon them. When-

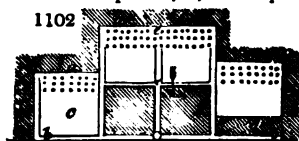
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ever these points are secured, the operation of cutting away the whole body of the coal begins. The place where the coal is removed, is named the or *gobb* waste; and gobbin, or gob-stuff, is stones or rubbish taken away from the coal, pavement, or roof, to fill up that excavation as much as possible, in order to prevent the crush of superincumbent strata from causing heavy falls, or following the workmen too fast in their descent. Coals mined in this manner work most easily according to the way in which the widest backs and cutters are; and therefore, in the Shropshire mode, the walls stand sometimes in one direction, and sometimes in another; the mine always turning out the best coals when the open backs and cutters face the workmen. As roads must be maintained through the crushed strata, the miners in the first place cut away about 15 feet of coal round the pit-bottom pillars, and along the upper sides of the dip-head chain walls; and then, at the distance of 9 or 10 feet, carry regular buildings of stone 3 feet broad, with props set flush with the faces of these, if necessary. As the miners advance, they erect small pillars of roof or pavement stone in regular lines with the wall face, and sometimes with props intermediate.

There are two principal modifications of the Shropshire plan. The first, or the original system, was to open out the wall round the pit-bottom; and, as the wall face extended, to set off main roads and branches, very like the branches of a tree. These roads were so distributed, that between the ends of any two branches there should be a distance of 30 or 40 yards, as might be most convenient. (see *fig. 1101.*) Each space of coal betwixt the roads is called a wall; and one half of the coals produced from each wall is carried to the one road, and the other half to the other road. This is a great convenience when the roof is bad; and hence a distance of only 20 yards betwixt the roads is in many instances preferred. In *fig. 1101.* *A* represents the shaft; *a*, the wall-face; *a*, the dip-head level; *b*, the roads, from 20 to 40 yards asunder; *c*, the *gobb* or waste, with buildings along the sides of the roads; and *d*, the pillars.

The other Shropshire system is represented in *fig. 1102.*, where *A* shows the pit, with the bottom pillars; *b*, the dip-head levels; *c*, the off-break from the level, where no



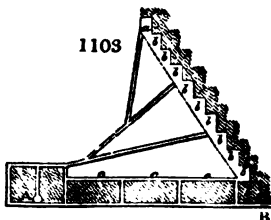
pillars are left; *d*, the off-break, where pillars remain to secure the level. All roads are protected in the sides by stone buildings, if they can be had, laid off 9 feet wide. After the crush settles, the roads generally remain permanently good, and can, in many cases, be travelled through as easily 50 years after they have been made, as at the first. Should

stones not be forthcoming, coals must be substituted, which are built about 20 inches in the base. In this method, the roads are likewise from 20 to 40 yards apart; but instead of ramifying, they are arranged parallel to each other. The miners secure the waste by gobbing; and three rows of props are carried forwards next the wall faces *a*, with pillars of stone or of coal reared betwixt them. This mode has a more regular appearance than the other; though it is not so generally practised.

In the post and stall system, each man has his own room, and performs all the labour of it; but in that of Shropshire, there is a division of labour among the workmen, who are generally divided into three companies. The first set curves or pools the coal along the whole line of walls, laying in or pooling at least 3 feet, and frequently 45 inches, or 5 quarters, as it is called. These men are named *holers*. As the crush is constantly following them, and impending over their heads, causing frequent falls of coal, they plant props of wood for their protection at regular distances in an oblique direction between the pavement and wall face. Indeed, as a further precaution, staples of coal, about 10 inches square, are left at every 6 or 8 yards, till the line of holing or curving is completed. The walls are then marked off into spaces of from 6 to 8 yards in length; and at each space a shearing or vertical cut is made, as deep as the holing; and when this is done, the *holer's* work is finished. The set who succeed the *holers*, are called *getters*. These commence their operations at the centre of the wall divisions, and drive out the *gibbs* and staples. They next set wedges along the roof, and bring down progressively each division of coal; or, if the roof be hard-bound, the coal is blown down with gunpowder. When the roof has a good parting, the coals frequently fall down the moment the *gibbs* are struck; which makes the work very easy. The *getters* are relieved in their turn by the third set, named *butty-men*, who break down the coals into pieces of a proper size for sending up the shaft, and take charge of turning out the coal from the wall face to the ends of the roads. This being done, they build up the stone pillars, fill up the *gobb*, set the trees, clear the wall faces of all obstructions, set the *gibbs*, and make every thing clear and open for the *holers* to resume their work. If the roads are to be heightened by taking down the roof, or removing the pavement, these *butty-men* do this work also, building forwards the sides of the roads, and securing them with the requisite props. When a coal has a following or roof stone, which regularly separates with the coal, this facilitates the labour, and saves much of the coal;

and should a soft bed of fire-clay occur a foot or two beneath the coal-seam, the holing is made in it, instead of into the coal, and the stone betwixt the holing and the coal benched down, which serves for pillars and gobbing. In this way all the vendible coal becomes available.

Another form of the Shropshire system is, for each miner to have from 6 to 12 feet of coal before him, with a leading-hand man; and for the several workmen to follow in succession, like the steps of a stair. When the coal has open backs and cutters, this work goes on very regularly, as represented in *fig. 1103*, where the leading miner is at *a*,



next to the outcrop, and *b b*, &c. are the wall faces of each workman; *A* being the shaft, and *B* the dip-head level. In this case the roads are carried either progressively through the gob, or the gob is entirely shut up; and the whole of the coals are brought down the wall-faces, either to the dip-head level or the road *c, c*. This method may be varied by making the walls broad enough to hold two, three, or four men when each set of miners performs the whole work of holing, getting, breaking down, and carrying off the coals.

It is estimated that from one-eighth to one-twelfth part only of the coals remains underground by the Shropshire plan; nay, in favourable circumstances, almost every inch of coal may be taken out, as its principle is to leave no solid pillars nor any coal below, except what may be indispensable for securing the gob. Indeed this system might be applied to coal seams of almost any ordinary thickness, providing stuff to fill up the gob could be conveniently procured.

In Great Britain, seams of coal are mined when they are only 18 inches thick; but if thinner, the working of fire-clay or ironstone immediately adjoining must be included. A few instances may be adduced, indeed, where caking coals of a fine quality for blacksmiths have been worked, though only in 12-inch seams.

Eighteen-inch seams are best worked by young lads and boys. The coal itself may be mined without lifting the pavement, or taking down the roof in the rooms; but roads must be out either in the pavement or the roof, for removing the coals to the pit-bottom. All coals less than 2 feet 3 inches thick, are worked with the view of taking out all the coal, either on the Shropshire system, or with pillar-walls and rooms; with this peculiarity, that, on account of the thinness of the seam, the rooms are worked as wide as the roof will bear up; or if a following of the roof-stone, or fall of it, can be brought on, it proves advantageous, by not only giving head-room, but by filling up the waste, and rendering the roads easily kept for the working of the pillars. Where no following takes place, small temporary pillars, about 8 feet square, are left along the chain-wall side. The walls may vary in thickness from 4 to 16 yards, according to circumstances, and they are holed through only for ventilation.

Coals from 5 to 8 feet thick are the best suited in every point of view for the effective work of the miner, and for the general economy of underground operations. When they exceed that thickness, they require very excellent roofs and pavements, to render the working either safe or comfortable; or to enable those who superintend the field to get out a fair proportion of coal from a given area. In such powerful beds the Shropshire method is impracticable, from want of gobbin; and long props, unless of prodigious girth, would present an inadequate resistance to the pressure of the massive ceiling.

When coals do not exceed 20 feet in thickness, and have good roofs, they are sometimes worked as one bed of coal; but if the coal be tender or free, it is worked as two beds. One-half of such thick coal, however, is in general lost in pillars; and it is very seldom that less than one-third can be left. When the coal is free and ready to crumble by the incumbent pressure, as well as by the action of the air, the upper portion of the coal is first worked, then a scaffolding of coal is left, 2 or 3 feet thick, according to the compactness of the coal; and the lower part of the coal is now worked, as shown in

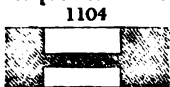


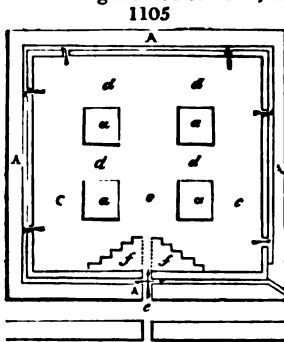
fig. 1104. As soon as the workings are completed to the proposed extent, the coal scaffoldings are worked away, and as much of the pillars as can be removed with safety. As propwood is of no use in coal seams of such a height, and as falls from the roof would prove

frequently fatal to the miners, it is customary with tender roofs to leave a ceiling of coal from 2 to 3 feet thick. This makes an excellent roof; and should it break, gives warning beforehand, by a peculiar crackling noise, very different from that of roof-stones crushing down.

One of the thickest coals in Great Britain, worked as one bed from roof to pavement, is the very remarkable seam near the town of Dudley, known by the name of the ten-yard coal, about 7 miles long, and 4 broad. No similar coal has been found in the island; and the mode of working it is quite peculiar, being a species of panel work

totally different from the modern Newcastle system. A compartment, or pannel, formed in working the coal, is called a side of work; and as the whole operation is exhibited in one of these compartments, it will be proper to describe the mode of taking the coal from one of them, before describing the whole extent of the workings of a mine.

Let *fig.* 1105. represent a side of work; *A*, the ribs or walls of coal left standing round, constituting the side of work; *a*, the pillars, 8 yards square; *e*, the stalls, 11 yards wide;



d, the cross openings, or through puts, also 11 yards wide; *e*, the bolt-hole, cut through the rib from the main road, by which bolt-hole the side of work is opened up, and all the coals removed. Two, three, or even four bolt-holes open into a side of work, according to its extent; they are about 8 feet wide, and 9 feet high. The working is in a great measure regulated by the natural fissures and joints of the coal-seam; and though it is 30 feet thick, the lower band, of 2 feet 3 inches, is worked first; the miners choosing to confine themselves within this narrow opening, in order to gain the greater advantage afterwards, in working the superjacent coal. Whenever the bolt hole is cut through, the work is opened up by driving a gallery forward, 4 feet wide, as shown by the dotted lines. At the sides of this gallery next the bolt-hole, each miner breaks off in succession a breast

of coal, two yards broad, as at *f, f*, by means of which the sides of the rib-walls *A*, are formed, and the area of the pillars. In this way each collier follows another, as in one of the systems of the Shropshire plan. When the side of work is laid open along the rib-walls, and the faces and sides of the pillars have been formed, the upper coals are then begun to be worked, next the rib-wall. This is done by shearing up to a bed next the bolt-hole, and on each side, whereby the head coals are brought regularly down in large cubical masses, of such thickness as suits with the free partings or subordinate divisions of the coals and bands. Props of wood, or even stone pillars, are placed at convenient distances for the security of the miners.

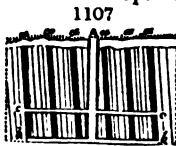
In working the ten-yard coal, a very large proportion of it is left underground, not merely in pillars and rib-walls, but in the state of small coal produced in breaking out the coal. Hence, from four-tenths to a half of the total amount is lost for ever.

Another method of working coal of uncommon thickness, is by scaffoldings or stages of coals, as practised in the great coal bed at Johnstone, near Paisley, of which a section has already been given. In one part of the field the coal is from 50 to 60 feet thick, and in another it amounts to 90 feet. The seams of stone interspersed through the

coal are generally inconsiderable, and amount in only two cases to 27 inches in thickness. The roof of the coal is so unbound, and the height so prodigious, that it could not possibly be worked in one seam, like that of Staffordshire. About 3 feet of the upper coal is therefore left as a roof, under which a band of coal, from 6 to 7 feet thick, is worked on the post and stall plan, with square pillars of extra strength, which are thereafter penetrated. A platform about 3 feet high is left at the sole; under which the rooms and pillars are set off and worked in another portion of the coal, from 5 to 7 feet thick, great care being had to place pillar under pillar, and partition under partition, to prevent a crush. Where the coal is thickest, no less than 10 bands of it are worked in this way, as is shown in *fig.* 1106. When any band of the coal is foul from sulphur or other causes, it is left for the next platform, so that a large proportion of it is lost, as in the Staffordshire mines. Much attention must here be paid to the vertical distribution of the pillars and apartments; the miner's compass must be continually consulted, and bore-holes must be put down through the coal scaffoldings, to regulate correctly the position of the pillars under one another.

Edge coals, which are nearly perpendicular, are worked in a peculiar manner; for the collier stands upon the coal, having the roof on the one hand, and the floor on the other, like two vertical walls. The engine-pit is sunk in the most powerful stratum. In some instances the same stratum is so vertical as to be sunk through for the whole depth of the shaft.

Whenever the shaft has descended to the required depth, galleries are driven across the strata from its bottom, till the coals are intersected, as is shown in *fig.* 1107., where we see the edge coals at *a, a*; *A*, the engine-pit; *b, b*, the transverse galleries from the bottom of the shaft; and *c, c*, upper transverse galleries, for the greater convenience of working the coal. The principal edge coal works in Great Britain lie in the neigh-



bourhood of Edinburgh, and the coals are carried on the backs of women from the wall-face to the bottom of the engine-pit.


The modes of carrying coals from the point where they are excavated to the pit bottom, are nearly as diversified as the systems of working.

One method employs hutches, or baskets, having slips or cradle feet shod with iron, containing from 2 to 3 hundred weight of coals. These baskets are dragged along the floor by ropes or leather harness attached to the shoulders of the workmen, who are either the colliers or persons hired on purpose. This method is used in several small collieries; but it is extremely injudicious, exercising the muscular action of a man in the most unprofitable manner. Instead of men, horses are sometimes yoked to these basket-hurdles, which are then made to contain from 4 to 6 hundred weight of coals; but from the magnitude of the friction, this plan cannot be commended.

An improvement on this system, where men draw the coals, is to place the basket or corve on a small four-wheeled carriage, called a tram, or to attach wheels to the corve itself. Thus much more work is performed, provided the floor be hard; but not on a soft pavement, unless some kind of wooden railway be laid.

The transport of coals from the wall-face to the bottom of the shaft, was greatly facilitated by the introduction of cast-iron railways, in place of wooden roads, first brought into practice by Mr. John Curr of Sheffield. The rails are called tram-rails, or plate-rails, consisting of a plate from 3 to 4 inches broad, with an edge at right angles to it about two inches and a half high. Each rail is from 3 to 4 feet long, and is fixed either to cross bearers of iron, called sleepers, or more usually to wooden bearers. In some collieries, the miners, after working out the coals, drag them along these railways to the pit bottom; but in others, two persons called trammers are employed to transport the coals; the one of whom, in front of the corve, draws with harness; and the other, called the patter, pushes behind. The instant each corve arrives, from the wall-face, at a central spot in the system of the railways, it is lifted from the tram by a crane placed there, and placed on a carriage called a rolley, which generally holds two corves. Whenever three or four rolleys are loaded, they are hooked together, and the rolley

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 driver, with his horse, takes them to the bottom of the engine-shaft. The rolley horses have a peculiar kind of shafts, commonly made of iron, named limbers, the purpose of which is to prevent the carriage from over-running them. One of these shafts is represented in *fig. 1108*. The hole shown at *a*, passes over an iron peg or stud in front of the rolley, so that the horse may be quickly attached or disengaged. By these arrangements the work is carried on with surprising regularity and despatch.

The power of the engine for drawing the coals up the shaft, is made proportional to the depth of the pit and the quantity to be raised, the corves ascending at an average velocity of about 12 feet per second. So admirable is the modern arrangement of this operation, that the corves are transported from the wall-faces to the pit bottom, and moved up the shaft, as fast as the onsets at the bottom, and the banksmen at the top, can hook the loaded and empty corves on and off the engine ropes. Thus 100 corves of coals have been raised every hour up a shaft 100 fathoms deep, constituting a lift of 27 tons per hour, or 324 tons in a day, or shift of 12 hours. Coals mined in large cubical masses cannot, however, be so rapidly raised as the smaller coal of the Newcastle district.

When coals have so great a rise from the pit bottom to the crop that horses cannot be used on the rolley ways, the corves descend along the tram-roads, by means of inclined-plane machines, which are moved either by vertical rope-barrels, or horizontal rope-sheaves. These inclined planes are frequently divided into successive stages, 200 or 300 yards long, at the end of each of which is an inclined-plane machine, whereby the coals are lowered from one level to another.

The wheels of the trams and rolleys vary in diameter from 8 to 16 inches, according to the thickness of the coal. In some, the axles not only revolve on their journals, but the wheels also revolve on their axles.

Various forms of machines have been employed for raising the coals out of the pits. The steam engine with fly-wheel and rope-barrels, is, however, now preferred in all considerable establishments. When of small power, they are usually constructed with a fly wheel, and short fly-wheel shaft, on which there is a small pinion working into the teeth of a large wheel, fixed upon the rope barrel. Thus the engine may move with great rapidity, while it imparts an equable slow motion to the corves ascending in the shaft. When the engines are of great power, however, they are directly connected with the rope-barrel; some of these being of such dimensions, that each revolution of the rope-barrel produces an elevation of 12 yards in the corve. A powerful brake is usually connected with the circumference of the fly-wheel or rope-barrel, whereby the brakeman, by applying his foot to the governing lever of the brake, and by shutting at the same time the steam valves with his hands, can arrest the corve, or pitch its arrival within a

few inches of the required height of every delivery. An endless chain, suspended from the bottom to the top of the shaft, has, in a few pits of moderate depth, been worked by a steam engine, for raising corves in constant succession; but the practice has not been found hitherto applicable on the greater scale.

There is a kind of water engines for raising coals, strictly admissible only in level free pits, where the ascent of the loaded corve is produced by the descent of a cassoos filled with water. When the ascent and descent are through equal spaces, the rope barrels for the cassoos and the corves are of equal diameter; but when the point from which the coals have to be lifted is deeper than the point of discharge for the water into the dry level, the cassoos must be larger, and the rope barrel smaller; so that by the time the cassoos reaches to the half-depth, for example, the corve may have mounted through double the space. The cassoos is filled with water at the pit mouth, and is emptied by a self-acting valve whenever it gets to the bottom. The loaded corve is replaced by an empty one at the pit mouth, and its weight, with that of the descending rope, pull up the empty cassoos; the motions of the whole mechanism being regulated by a powerful brake.

Various plans have been devised to prevent collision between the ascending and descending corves, which sometimes pass each other with a joint velocity of 20 or 30 feet per second. One method is by dividing the pit from top to bottom, so that each corve moves in a separate compartment. Another mode was invented by Mr. Curr of Sheffield, in which wooden guides were attached from top to bottom of the pit; being spars of deal about 4 inches square, attached perpendicularly to the sides of the shaft, and to buntons in the middle of the pit. Betwixt these guides, friction-roller sliders are placed, attached to the gin-ropes, to which sliders the corves are suspended. In this way, the corves can be raised with great rapidity; but there is a considerable loss of time in banking the corve at the pit mouth, where shutters or sliding boards must be used. This plan is highly beneficial where the coals are in large lumps.

Both ropes and chains are used for lifting coals. The round ropes are shroud-laid; but the preferable rope is the flat band, made of four ropes placed horizontally together, the ropes being laid alternately right and left. In this way, the ropes counteract one another in the twist, hanging like a ribbon down the shaft; and are stitched strongly together by a small cord. Such rope bands are not only very pliable for their strength, which protects the heart of the rope from breaking, but as they lap upon themselves, a simple sheave serves as a rope-barrel. They possess the additional advantage, that by so lapping, they enlarge the diameter of the axle in which they coil, and thus make a compensation mechanically against the increasing length of rope descending with its corve. Thus the counterpoise chains, used in deep pits to regulate the descent, have been superseded. See ROPE-SPINNING.

When chains are preferred to ropes, as in very deep pits, the short pudding-link chains are mostly used. See CABLE.

The corves after being landed or banked at the pit mouth, are drawn to the bin or coal-hill, either upon slips by horses, or by trammers on a tram-road. But with small coals, like the Newcastle, the pit head is raised 8 or 9 feet above the common level of the ground, and the coal-heap slopes downwards from that height. As the bins increase, tram-roads are laid outwards upon them.

I shall now describe the *ventilation* of coal mines. Into their furthest recesses, an adequate supply of fresh air must be carried forwards, for the purposes of respiration, and the combustion of candles; as also for clearing off the carbonic acid and carburetted hydrogen gases, so destructive to the miners, who call these noxious airs, from their most obvious qualities, choke-damp and fire-damp.

Before the steam engine was applied to the drainage of the mines, and the extraction of the coal, the excavations were of such limited extent, that when inflammable air accumulated in the foreheads, it was usual in many collieries to fire it every morning. This was done by fixing a lighted candle to the end of a long pole, which being extended towards the roof by a person lying flat on the floor, the gas was fired, and the blast passed safely over him. If the gas was abundant, the explosive miner put on a wet jacket, to prevent the fire from scorching him. In other situations, where the fire-damp was still more copious, the candle was drawn forwards into it, by a cord passing over a catch at the end of the gallery, while the operator stood at a distance. This very rude and dangerous mode of exploding the inflammable gas, is still practised in a few mines, under the name of the firing line.

The carbonic acid or choke-damp having a greater specific gravity than atmospheric air, in the proportion of about 3 to 2, occupies the lower part of the workings, and gives comparatively little annoyance. Its presence may moreover be always safely ascertained by the lighted candle. This cannot, however, be said of the fire-damp, which being lighter and more movable, diffuses readily through the atmospheric air, so as to form a most dangerous explosive mixture, even at a considerable distance from

the blowers or sources of its extrication from the coal strata. Pure subcarburetted hydrogen has a specific gravity = 0,555, air being 1; and consists of a volume of vapour of carbon, and two volumes of hydrogen, condensed by mutual affinity into one volume. The choke-damp is a mixture of the above, with a little carbonic acid gas, and variable proportions of atmospheric air. As the pure subcarburetted hydrogen requires twice its bulk of oxygen to consume it completely, it will take for the same effect about 10 times its bulk of atmospheric air, since this volume of air contains about two volumes of oxygen. Ten volumes of air, therefore, mixed with one volume of subcarburetted hydrogen, form the most powerfully explosive mixture. If either less or more air be intermixed, the explosive force will be impaired; till 9 volumes of air below or above that ratio, constitute non-explosive mixtures; that is, 1 of the pure fire-damp mixed with either 7 or 13 of air, or any quantity below the first, or above the second number, will afford an unexplosive mixture. With the first proportion, a candle will not burn; with the second, it burns with a very elongated blue flame. The fire-damp should therefore be still further diluted with common air, considerably beyond the above proportion of 1 to 13, to render the working of the mine perfectly safe.

These noxious gases are disengaged from the cutters, fissures, and minute pores of the coal; and if the quantity be considerable, relative to the orifice, a hissing noise is heard.

Though the choke-damp, or carbonic acid gas, be invisible, yet its line of division from the common air is distinctly observable on approaching a lighted candle to the

1109

lower level, where it accumulates, which becomes extinguished the instant it comes within its sphere, as if it were plunged in water. The stratum of carbonic acid sometimes lies 1 or 2 feet thick on the floor, while the superincumbent air is perfectly good. When the coal has a considerable dip and rise, the choke-damp will be found occupying the lower parts of the mine, in a wedge form, as represented in *fig. 1109*, where *a* shows the place of the carbonic acid gas, and *b* that of the common air.

When a gallery is driven in advance of the other workings, and a discharge of this gas takes place, it soon fills the whole mine, if its direction be in the line of level, and the mine is rendered unworkable until a supply of fresh air is introduced to dislodge it. As the flame of a candle indicates correctly the existence of the choke-damp, the miners may have sufficient warning of its presence, so as to avoid the place which it occupies, till adequate means be taken to drive it away.

The fire-damp is not an inmate of every mine, and is seldom found, indeed, where the carbonic acid prevails. It occurs in the greatest quantities in the coal mines of the counties of Northumberland, Durham, Cumberland, Staffordshire, and Shropshire. It is more abundant in coals of the caking kind, with a bright steel-grained fracture, than in cubic coals of an open-burning quality. Splint coals are still less liable to disengage this gas. In some extensive coal-fields it exists copiously on one range of the line of bearing, while on the other range, none of it is observed, but abundance of carbonic acid gas.

In the numerous collieries in the Lothians, south from the city of Edinburgh, the fire-damp is unknown; while in the coal-fields round the city of Glasgow, and along the coast of Ayrshire, it frequently appears.

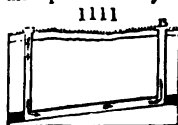
The violent discharge of the gas from a crevice or cutter of the coal, is called a blower; and if this be ignited, it burns like an immense blowpipe, inflaming the coal at the opposite side of the gallery. The gas evidently exists in a highly compressed and elastic state; whence it seems to loosen the texture of the coals replete with it, and renders them more easily worked. The gas is often peculiarly abundant near a great dislocation or slip of the strata; so that the fissure of the dislocation will sometimes emit a copious stream of gas for many years. It has also happened, that from certain coals, newly worked, and let fall from a height into the hold of a vessel, so much inflammable gas has been extricated that, after the hatches were secured, and the ship ready to proceed to sea, the gas has ignited with the flame of a candle, so as to scorch the seamen, to blow up the decks, and otherwise damage the vessel. In like manner, when the pillars in a mine are crushed by sudden pressure, a great discharge of gas ensues. This gas being lighter than common air, always ascends to the roof or to the rise of the galleries; and, where the dip is considerable, occupies the forehead of the

1110

mine, in a wedge form, as shown in *fig. 1110*, where *a* represents the fire-damp, and *b* the common air. In this case, a candle will burn without danger near the point *c*, close to the floor; but if it be advanced a few feet further towards the roof, an explosion will immediately ensue; since at the line where the two elastic fluids are in contact, they mix, and form an explosive body.

When this gas is largely diluted with air, the workmen do not seem to feel any inconvenience from breathing the mixture for a period of many years; but on inhaling pure carburetted hydrogen, the miner instantly drops down insensible, and, if not speedily removed into fresh air, he dies.

The production of these noxious gases renders ventilation a primary object in the system of mining. The most easily managed is the carbonic acid. If an air-pipe has been carried down the engine pit for the purpose of ventilation in the sinking other pipes are connected with it, and laid along the pavement, or are attached to an angle of the mine next the roof. These pipes are prolonged with the galleries, by which means the air at the forehead is drawn up the pipes and replaced by atmospheric air, which descends by the shaft in an equable current, regulated by the draught of the furnace at the pit mouth. This circulation is continued till the miners cut through upon the second shaft, when the air-pipes become superfluous; for it is well known that the instant such communication is made, as is represented in *fig. 1111*, the air spontaneously descends in the engine pit *A*, and, passing along the gallery *a*,



ascends in a steady current in the second pit *B*. The air, in sinking through *A*, has at first the atmospheric temperature, which in winter may be at or under the freezing point of water; but its temperature increases in passing down through the relatively warmer earth, and ascends in the shaft *B*, warmer than the atmosphere. When shafts are of unequal depths, as represented in the figure, the current of air flows pretty uniformly in one direction. If the second shaft has the same depth with the first, and the bottom and mouth of both be in the same horizontal plane, the air would sometimes remain at rest, as water would do in an inverted syphon, and at other times would circulate down one pit and up another, not always in the same direction, but sometimes up the one, and sometimes up the other, according to the variations of temperature at the surface, and the barometrical pressures, as modified by winds. There is in mines a proper heat, proportional to their depth, increasing about one degree of Fahrenheit's scale for every 60 feet of descent.

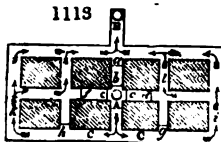
There is a simple mode of conducting air from the pit bottom to the forehead of the mine, by cutting a ragglin, or trumpeting, as it is termed, in the side of the gallery, as re-

presented *fig. 1112*, where *A* exhibits the gallery in the coal, and *B* the ragglin, which is from 15 to 18 inches square. The coal itself forms three sides of the air-pipe, and the fourth is composed of thin deals applied air-tight, and nailed to small props of wood fixed between the top and bottom of the lips of the ragglin. This mode is very generally adopted in running galleries of communication, and dip-head level galleries, where carbonic acid abounds, or when from the stagnation of the air the miners' lights burn dimly.

When the ragglin or air-pipes are not made spontaneously active, the air is sometimes impelled through them by means of ventilating fanners, having their tube placed at the pit bottom, while the vanes are driven with great velocity by a wheel and pinion worked with the hand. In other cases, large bellows like those of the blacksmith, furnished with a wide nozzle, are made to act in a similar way with the fanners. But these are merely temporary expedients for small mines. A very slight circulation of air can be effected by propulsion, in comparison of what may be done by exhaustion; and hence it is better to attach the air-pipe to the valve of the bellows, than to their nozzle.

Ventilation of collieries has been likewise effected on a small scale, by attaching a horizontal funnel to the top of air-pipes elevated a considerable height above the pit mouth. The funnel revolves on a pivot, and by its tail-piece places its mouth so as to receive the wind. At other times, a circulation of air is produced by placing coal-fires in iron grates, either at the bottom of an upcast pit, or suspended by a chain a few fathoms down.

Such are some of the more common methods practised in collieries of moderate depth, where carbonic acid abounds, or where there is a total stagnation of air. But in all great coal mines the aerial circulation is regulated and directed by double doors, called main or bearing doors. These are true air-valves, which intercept a current of air moving in one direction from mixing with another moving in a different direction. Such valves are placed on the main roads and passages of the galleries, and are essential to a just ventilation. Their functions are represented in the annexed *fig. 1113*, where *A* shows the downcast shaft, in which the aerial current is made to descend; *B* is the upcast shaft, sunk towards the rise of the coal; and *C*, the dip-head level. Were the mine here figured to be worked without any attention to the circulation, the air would flow down the pit *A*, and proceed in a direct line up



the rise mine to the shaft *B*, in which it would ascend. The consequence would therefore be, that all the galleries and boards to the dip of the pit *A*, and those lying on each side of the pits, would have no circulation of air; or, in the language of the collier, would be laid dead. To obviate this result, double doors are placed in three of the galleries adjoining the pit; viz., at *a* and *b*, *c* and *d*, *e* and *f*; all of which open inwards to the shaft *A*. By this plan, as the air is not suffered to pass directly from the shaft *A* to the shaft *B*, through

the doors *a* and *b*, it would have taken the next shortest direction by *c d* and *e f*; but the doors in these galleries prevent this course, and compel it to proceed downwards to the dip-head level *c*, where it will spread or divide, one portion pursuing a route to the right, another to the left. On arriving at the boards *g* and *h*, it would have naturally ascended by them; but this it cannot do, by reason of the building or stopping placed at *g* and *h*. By means of such stoppings placed in the boards next the dip-head level, the air can be transported to the right hand or to the left for many miles, if necessary, providing there be a train or circle of aerial communication from the pit *A* to the pit *B*. If the boards *i* and *k* are open, the air will ascend in them, as traced out by the arrows; and after being diffused through the workings, will again meet in a body at *a*, and mount the gallery to the pit *B*, sweeping away with it the deleterious air which it meets in its path. Without double doors on each main passage, the regular circulation of the air would be constantly liable to interruptions and derangements; thus, suppose the door *c* to be removed, and only *d* to remain in the left hand gallery, all the other doors being as represented, it is obvious, that whenever the door *d* is opened, the air, finding a more direct passage in that direction, would mount by the nearest channel *l*, to the shaft *B*, and lay dead all the other parts of the work, stopping all circulation. As the passages on which the doors are placed constitute the main roads by which the miners go to and from their work, and as the corves are also constantly wheeling along all the time, were a single door, such as *d*, so often opened, the ventilation would be rendered precarious or languid. But the double doors obviate this inconvenience; for both men and horses, with the corves, in going to or from the pit bottom *A*, no sooner enter the door *d*, than it shuts behind them, and encloses them in the still air contained between the doors *d* and *c*; *c* having prevented the air from changing its proper course while *d* was open. When *d* is again shut, the door *c* may be opened without inconvenience, to allow the men and horses to pass on to the pit bottom at *A*; the door *d* preventing any change in the aerial circulation while the door *c* is open. In returning from the pit, the same rule is observed, of shutting one of the double doors, before the other is opened.

If this mode of disjoining and insulating air-courses from each other be once fairly conceived, the continuance of the separation through a working of any extent, may be easily understood.

When carbonic acid gas abounds, or when the fire-damp is in very small quantity, the air may be conducted from the shaft to the dip-head level, and by placing stoppings of each room next the level, it may be carried to any distance along the dip-head levels; and the furthest room on each side being left open, the air is suffered to diffuse itself through the wastes, along the wall faces, and mount in the upcast pit, as is represented in *fig. 1099*. But should the air become stagnant along the wall faces, stoppings are set up throughout the galleries, in such a way as to direct the main body of fresh air along the wall faces for the workmen, while a partial stream of air is allowed to pass through the stoppings, to prevent any accumulation of foul air in the wastes.

In very deep and extensive collieries more elaborate arrangements for ventilation are introduced. Here the circulation is made active by rarefying the air at the upcast shaft, by means of a very large furnace placed either at the bottom or top of the shaft. The former position is generally preferred. *Fig. 1091*, exhibits a furnace placed at the top of the pit. When it surmounts a single pit, or a single division of the pit, the compartment intended for the upcast is made air-tight at top, by placing strong buntons or beams across it, at any suitable distance from the mouth. On these buntons a close scaffolding of plank is laid, which is well plastered or coated over with adhesive plastic clay. A little way below the scaffold, a passage is previously cut, either in a sloping direction, to connect the current of air with the furnace, or it is laid horizontally, and then communicates with the furnace by a vertical opening. If any obstacle prevent the scaffold from being erected within the pit, this can be made air-tight at top, and a brick flue carried thence along the surface to the furnace.

The furnace has a size proportional to the magnitude of the ventilation, and the chimneys are either round or square, being from 50 to 100 feet high, with an inside diameter of from 5 to 9 feet at bottom, tapering upwards to a diameter of from 2½ feet to 5 feet. Such stalks are made 9 inches thick in the body of the building, and a little thicker at bottom, where they are lined with fire-bricks.

The plan of placing the furnace at the bottom of the pit is, however, more advantageous, because the shaft through which the air ascends to the furnace at the pit mouth, is always at the ordinary temperature; so that whenever the top furnace is neglected, the circulation of air throughout the mine becomes languid, and dangerous to the workmen; whereas, when the furnace is situated at the bottom of the shaft, its sides get heated, like those of a chimney, through its total length, so that though the heat of the furnace be accidentally allowed to decline or become extinct for a little, the circu-

lation will still go on, the air of the upcast pit being rarefied by the heat remaining in the sides of the shaft.

To prevent the annoyance to the onsetters at the bottom, from the hot smoke, the following plan has been adopted, as shown in the wood-cut, *fig. 1114*. where *a* represents the lower part of the upcast shaft; *b*, the furnace, built of brick, arched at top, with its sides insulated from the solid mass of coal which surrounds it. Between the furnace wall and the coal-beds, a current of air constantly passes towards the shaft, in order to prevent the coal catching fire. From the end of the furnace a gallery is cut in a rising direction at *c*, which communicates with the shaft at *d*, about 7 or 8 fathoms from the bottom of the pit. Thus the furnace and furnace-keeper are completely disjoined from the shaft; and the pit bottom is not only free

from all encumbrances, but remains comfortably cool. To obviate the inconveniences from the smoke to the banksmen in landing the coals at the pit mouth, the following plan has been contrived for the Newcastle collieries. *Fig. 1115*. represents the mouth of the pit; *a* is the upcast shaft, provided with a furnace at bottom; *b*, the downcast shaft, by which the supply of atmospheric air descends; and *d*, the brattice carried above the pit mouth. A little way below the settle-boards, a gallery *c*, is pushed, in communication with the surface from the downcast shaft, over which a brick tube or chimney is built from 60 to 80 feet high, 7 or 8 feet diameter at bottom, and 4 or 5 feet diameter at

top. On the top of this chimney a deal funnel is suspended horizontally on a pivot, like a turn-cap. The vane *f*, made also of deal, keeps the mouth of the funnel always in the same direction with the wind. The same mechanism is mounted at the upcast shaft *a*, only here the funnel is made to present its mouth in the wind's eye. It is obvious from the figure, that a highwind will rather aid than check the ventilation by this plan.

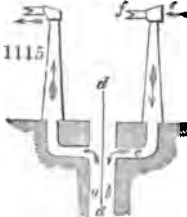
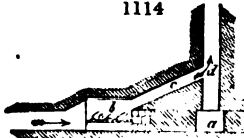
The principle of ventilation being thus established, the next object in opening up a colliery, and in driving all galleries whatever, is the *double mine* or *double headways course*; on the simple but very ingenious distribution of which, the circulation of air depends at the commencement of the excavations.

The double headways course is represented in *fig. 1116*, where *a* is the one heading or gallery, and *b* the other; the former being immediately connected with the upcast side of the pit *c*, and the latter with the downcast side of the pit *d*.

The pit itself is made completely air-tight by its division of deals from top to bottom, called the brattice wall; so that no air can pass through the brattice from *d* to *c*, and the intercourse betwixt the two currents of air is completely intercepted by a stopping betwixt the pit bottom and the end of the first pillar of coal; the pillars or walls of coal, marked *e*, are called stenting walls; and the openings betwixt them, walls or thirlings. The arrows show the direction of the air. The headings *a* and *b* are generally made about 9 feet wide, the stenting walls 6 or 8 yards thick, and are holed or thirled at such a distance as may be most suitable for the state of the air. The thirlings are 5 feet wide.

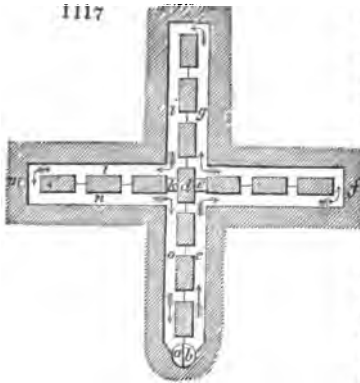
When the headings are set off from the pit bottom, an aperture is left in the brattice at the end of the pillar next the pit, through which the circulation betwixt the upcast and downcast pits is carried on; but whenever the workmen cut through the first thirling No. 1., the aperture in the brattice at the pit bottom is shut; in consequence of which the air is immediately drawn by the power of the upcast shaft through that thirling as represented by the dotted arrow. Thus a direct stream of fresh air is obviously brought close to the forehead where the mines are at work. The two headings *a* and *b* are then advanced, and as soon as the thirling No. 2. is cut through, a wall of brick and mortar, 4½ inches thick, is built across the thirling No. 1. This wall is termed a stopping; and being air-tight, it forces the whole circulation through the thirling No. 2. In this manner the air is always led forward, and caused to circulate always by the last-made thirling next the forehead; care being had, that whenever a new thirling is made, the last thirling through which the air was circulated, be secured with an air-tight stopping. In the woodcut, the stoppings are placed in the thirlings numbered 1, 2, 3, 4, 5, 6, and of consequence the whole circulation passes through the thirling No. 7., which lies nearest the foreheads of the headings *a*, *b*. By inspecting the figure, we observe, that on this very simple plan, a stream of air may be circulated to any required distance, and in any direction, however tortuous. Thus, for example, if while the double headways course *a*, *b*, is pushed forward, other double headways courses are required to be carried on at the same time on both sides of the first headway, the same general principles have only to be attended to as shown in *fig. 1117*., where

1114



1116





a is the upcast, and b the downcast shaft. The air advances along the heading c, but cannot proceed further in that direction than the pillar d, being obstructed by the double doors at e. It therefore advances in the direction of the arrows to the foreheads at f, and passing through the last thirling made there, returns to the opposite side of the double doors, ascends now the heading g to the foreheads at h, passes through the last-made thirling at that point, and descends, in the heading i, till it is interrupted by the double doors at k. The aerial current now moves along the heading l, to the foreheads at m, returns by the last-made thirling there, along the heading n, and finally goes down the heading o, and mounts by the upcast shaft a, carrying with it all the noxious gases which it encountered during its circuitous journey.

This wood-cut is a faithful representation of the system by which collieries of the greatest extent are worked and ventilated. In some of these, the air courses are from 30 to 40 miles long. Thus the air conducted by the medium of a shaft divided by a brattice wall only a few inches thick, after descending in the downcast in one compartment of the pit at 6 o'clock in the morning, must thence travel through a circuit of nearly 30 miles, and cannot arrive at its reascending compartment on the other side of the brattice, or pit partition, till 6 o'clock in the evening, supposing it to move all the time at the rate of $2\frac{1}{2}$ miles per hour. Hence we see that the *primum mobile* of this mighty circulation, the furnace, must be carefully looked after, since its irregularities may affect the comfort, or even the existence of hundreds of miners spread over these vast subterraneous labyrinths. On the principles just laid down, it appears, that if any number of boards be set off from any side of these galleries, either in a level, dip, or rise direction, the circulation of air may be advanced to each forehead, by an ingoing and returning current.

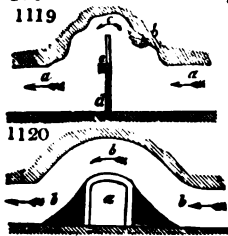
Yet while the circulation of fresh air is thus advanced to the last-made thirling next the foreheads f, h, and m, fig. 1117., and moves through the thirling which is nearest to the face of every board and room, the emission of fire-damp is frequently so abundant from the coal strata, that the miners dare not proceed forwards more than a few feet from that aerial circulation, without hazard of being burned by the combustion of the gas at their candles. To guard against this accident, temporary shifting brattices are employed. These are formed of deal, about $\frac{3}{4}$ of an inch thick, 3 or 4 feet broad, and 10 feet long; and are furnished with cross-bars for binding the deals together, and a few finger loops cut through them, for lifting them more expeditiously, in order to place them in a proper position. Where inflammable air abounds, a store of such brattice deals should be kept ready for emergencies.

The mode of applying these temporary brattices, or deal partitions, is shown in the accompanying figure (1118.), which shows how the air circulates freely through the

1118

 ing boards or rooms, which are so full of inflammable air as to be unworkable. Props are now erected near the upper end of the pillar e, betwixt the roof and pavement, about two feet clear of the sides of the next pillar, leaving room for the miner to pass along between the pillar side and the brattice. The brattices are then fastened with nails to the props, the lower edge of the under brattice resting on the pavement, while the upper edge of the upper is in contact with the roof. By this means any variation of the height in the bed of coal is compensated by the overlap of the brattice boards; and as these are advanced, shifting brattices are laid close to, and alongside of, the first set. The miner next sets up additional props in the same parallel line with the former, and slides the brattices forwards, to make the air circulate close to the forehead where he is working; and he regulates the distance betwixt the brattice and the forehead by the disengagement of fire-damp and the velocity of the aerial circulation. The props are shown at d d, and the brattices at f, f. By this arrangement the air is prevented from passing directly through the thirling a, and is forced along the right-hand side of the brattice, and, sweeping over the wall face or forehead, returns by the back of the brattice, and passes through the thirling a. It is prevented, however, from returning in its former direction by the brattice planted in the forehead e, where-by it mounts up and accomplishes its return close to that forehead. Thus headways and boards are ventilated till another thirling is made at the upper part of the pillar. The thirling a is then closed by a brick stopping, and the brattice boards removed forward for a similar operation.

When blowers occur in the roof, and force the strata down, so as to produce a large vaulted excavation, the accumulated gas must be swept away; because, after filling that space, it would descend in an unmixed state under the common roof of the coal. The manner of removing it is represented in *fig. 1119.*, where *a* is the bed of coal,



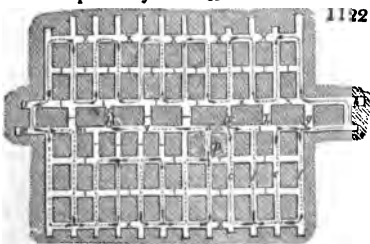
1119 *b* the blower, *c* the excavation left by the downfall of the roof, *d* is a passing door, and *e* a brattice. By this arrangement the aerial current is carried close to the roof, and constantly sweeps off or dilutes the inflammable gas of the blower, as fast as it issues. The arrows show the direction of the current; but for which, the accumulating gas would be mixed in explosive proportions with the atmospheric air, and destroy the miners.

There is another modification of the ventilating system, where the air-courses are traversed across; that is, when one air-course is advanced at right angles to another, and must pass it in order to ventilate the workings on the further side. This is accomplished on the plan shown in *fig. 1120.*, where *a* is a main road with an air-course, over which the other air-course *b*, has to pass. The sides of this air channel are built of bricks arched over so as to be air-tight, and a gallery is driven in the roof strata as shown in the figure. If an air-course, as *a*, be laid over with planks made air-tight, crossing and recrossing may be effected with facility. The general velocity of the air in these ventilating channels is from 3 to 4 feet per second, or about $2\frac{1}{2}$ miles per hour, and their internal dimensions vary from 5 to 6 feet square, affording an area of from 25 to 36 square feet.

Mr. Taylor's hydraulic air-pump, formerly described, p. 173. deserves to be noticed among the various ingenious contrivances for ventilating mines, particularly when they are of moderate extent. *a* is a large wooden tub, nearly filled with water, through whose bottom the ventilating pipe *b* passes down into the recesses of the mine. Upon the top of *b*, there is a valve *c*, opening upwards. Over *b*, the gasometer vessel is inverted in *a*, having a valve also opening outwards at *d*. When this vessel is depressed by any moving force, the air contained within it is expelled through *d*; and when it is raised, it diminishes the atmospherical pressure in the pipe *b*, and thus draws air out of the mine into the gasometer; which cannot return on account of the valve at *c*, but is thrown out into the atmosphere through *d* at the next descent.

The general plan of distributing the air, in all cases, is to send the first of the current that descends in the downcast shaft among the horses in the stables, next among the workmen in the foreheads, after which the air, loaded with whatever mixtures it may have received, is made to traverse the old wastes. It then passes through the furnace with all the inflammable gas it has collected, ascends the upcast shaft, and is dispersed into the atmosphere. This system, styled *coursing the air*, was invented by Mr. Spedding of Cumberland. According to the quantity of the fire-damp, the coursing is conducted either up one room, and returned by the next alternately, through the whole extent of the works, or it passes along 2 or 3 connected rooms, and returns by the same number.

This admirable system has received the greatest improvements from the mining engineers of the Newcastle district, and especially from Mr. Buddle of Wallsend. His plan being a most complete scale of ventilation, where the aerial current is made to sweep every corner of the workings, is shown in *fig. 1122.*; in which *a*



1122 represents the downcast, and *b* the upcast shaft. By pursuing the track of the arrows, we may observe that the air passes first along the two rooms *c, d*, having free access to each through the walls, but is hindered from entering into the adjoining rooms by the stoppings which form the air-courses. It sweeps along the wall faces of the rooms *c, d*, and makes a return down the rooms *e, f*, but is not allowed to proceed further in that direction by the stoppings *g, h*. It then proceeds to the foreheads *i, k*, and single courses all the rooms to the foreheads *l, m*; from this point it would go directly to the upcast pit *b*, were it not prevented by the stopping *n*, which throws it again into double coursing the rooms, till it arrives at *o*, whence it goes directly to the furnace, and ascends the shaft *b*. The lines across each other represent the passing doors; and these may be substituted in any place for a passage where there is a stopping. The stopping *p*, near the bottom of the downcast shaft, is termed a main stopping; because if it were removed, the whole circulation would instantly cease, and the air, instead of

traversing in the direction of the arrows, would go directly from the downcast pit *a*, to the upcast pit *b*, along the gallery *g*. Hence every gallery and room of the workings would be laid *dead*, as it is termed, and be immediately filled with fire-damp, which might take fire either at the workmen's candles, or at the furnace next the upcast shaft *b*. Thus also a partial stagnation in one district of the colliery, would be produced by any of the common stoppings being accidentally removed or destroyed, since the air would thereby always pursue the nearest route to the upcast pit. Main stoppings are made particularly secure, by strong additional stone buildings, and they are set up at different places, to maintain the main air courses entire in the event of an explosion; by which precautions great security is given to human life. This system of ventilation may be extended to almost any distance from the pit-bottom, provided the volume of fresh air introduced be adequate to dilute sufficiently the fire-damp, so that the mixture shall not reach the explosive point. The air, by this management, ventilates first one panel of work, and then other panels in succession, passing onwards through the barriers or panel walls, by means of galleries, as in *fig. 1100*, by the principle either of single, double, or triple couraing, according to the quantity of gas in the mine.

In ventilating the very thick coal of Staffordshire, though there is much inflammable air, less care is needed than in the north of England collieries, as the workings are very roomy, and the air courses of comparatively small extent. The air is conducted down one shaft, carried along the main roads, and distributed into the sides of work, as shown in *fig. 1105*. A narrow gallery, termed the air-head, is carried in the upper part of the coal, in the rib walls, along one or more of the sides. In the example here figured, it is carried all round, and the air enters at the bolt-hole *e*. Lateral openings, named spouts, are led from the air-head gallery into the side of work; and the circulating stream mixed with the gas in the workings, enters by these spouts, as represented by the arrows, and returns by the air-head at *g*, to the upcast pit.

When the fire-damp comes off suddenly in any case, rendering the air foul and explosive at the foreheads, if no other remedy be found effectual, the working of the coal must be suspended, and a current of air sent directly from the fresh in-going stream, in order to dilute the explosive mixture, before it reaches the furnace. This is termed *skailing the air*; for otherwise the gas would kindle at the furnace, and flame backwards, like a train of gunpowder, through all the windings of the work, carrying devastation and death in its track. By *skailing* the air, however, time is given for running forward with water, and drowning the furnace. A cascade of water from the steam engine pumps is then allowed to fall down the pit, the power of which through a fall of 500 or 600 feet, is so great in carrying down a body of air, that it impels a sufficient current through every part of the workings. The ventilation is afterwards put into its usual train at leisure.

In collieries which have been worked for a considerable time, and particularly in such as have goaves, creeps, or crushed wastes, the disengagement of the fire-damp from these recesses is much influenced by the state of atmospheric pressure. Should this be suddenly diminished, as shown by the fall of the barometer, the fire-damp suddenly expands and comes forth from its retirement, polluting the galleries of the mine with its noxious presence. But an increase of barometric pressure condenses the gases of the mine, and restrains them within their sequestered limits. It is therefore requisite that the coal-viewer should consult the barometer before inspecting the subterraneous workings of an old mine, on the Monday mornings, in order to know what precautions must be observed in his personal survey.

The catastrophe of an explosion in an extensive coal-mine is horrible in the extreme. Let us imagine a mine upwards of 100 fathoms deep, with the workings extended to a great distance under the surrounding country, with machinery complete in all its parts, the mining operations under regular discipline, and railways conducted through all its ramifications; the stoppings, passing doors, brattices, and the entire economy of the mine, so arranged that every thing moves like a well regulated machine. A mine of this magnitude at full work is a scene of cheering animation, and happy industry; the sound of the hammer resounds in every quarter, and the numerous carriages, loaded or empty, passing swiftly to and fro from the wall faces to the pit bottom, enliven the gloomiest recesses. At each door a little boy, called a trapper, is stationed, to open, and shut it. Every person is at his post, displaying an alacrity and happiness pleasingly contrasted with the surrounding gloom. While things are in this merry train, it has but too frequently happened that from some unforeseen cause, the ventilation has partially stagnated, allowing a quantity of the fire-damp to accumulate in one space to the explosive pitch; or a blower has suddenly sprung forth, and the unsuspecting miner entering this fatal region with his candle, sets the whole in a blaze of burning air, which immediately suffocates and scorches to death every living creature within its sphere, while multitudes beyond the reach of the flame are dashed to pieces by the force of the explosion, rolling like thunder along the winding galleries. Sometimes the explosive flame

seems to linger in one district for a few moments; then gathering strength for a giant effort, it rushes forth from its cell with the violence of a hurricane, and the speed of lightning, destroying every obstacle in its way to the upcast shaft. Its power seems to be irresistible. The stoppings are burst through, the doors are shivered into a thousand pieces; while the unfortunate miners, men, women, and boys, are swept along with an inconceivable velocity, in one body, with the horses, carriages, corves, and coals. Should a massive pillar obstruct the direct course of the aerial torrent, all these objects are dashed against it, and there prostrated or heaped up in a mass of common ruin, mutilation, and death. Others are carried directly to the shaft, and are either buried there amid the wreck, or are blown up and ejected from the pit mouth. Even at this distance from the explosive den, the blast is often so powerful, that it frequently tears the brattice walls of the shaft to pieces, and blows the corves suspended in the shaft as high up into the open air as the ropes will permit. Not unfrequently, indeed, the ponderous pulley-wheels are blown from the pit-head frame, and carried to a considerable distance in the bosom of a thick cloud of coals and coal-dust brought up from the mine by the fire-damp, whose explosion shakes absolutely the superincumbent solid earth itself with a mimic earthquake. The dust of the ruins is sometimes thrown to such a height above the pit as to obscure the light of the sun. The silence which succeeds to this awful turmoil is no less formidable; for the atmospheric back-draught, rushing down the shaft, denotes the consumption of vital air in the mine, and the production of the deleterious choke-damp and azote.

Though many of the miners may have escaped by their distance in the workings from the destructive blast and the fire, yet their fate may perhaps be more deplorable. They hear the explosion, and are well aware of its certain consequences. Every one anxious to secure his personal safety, strains every faculty to reach the pit-bottom. As the lights are usually extinguished by the explosion, they have to grope their way in utter darkness. Some have made most marvellous escapes, after clambering over the rubbish of fallen roofs, under which their companions are entombed; but others wandering into uncertain alleys, tremble lest they should encounter the pestilential air. At last they feel their power, and aware that their fate is sealed, they cease to struggle with their inevitable doom; they deliberately assume the posture of repose, and fall asleep in death. Such has been too often the fate of the hardy and intelligent miners who immure themselves deep beneath the ground, and venture their lives for the comfort of their fellow-men; and such frequently is the ruinous issue of the best ordered and most prosperous mining concerns.

In such circumstances the mining engineers or coal viewers have a dangerous and difficult duty to perform. The pit into which they must descend as soon as possible, is rendered unsafe by many causes; by the wrecks of loose timber torn away by the eruption, or by the unrespirable gases; by the ignition perhaps of a portion of the coal itself, or by the flame of a blower of fire-damp; either of which would produce violent and repeated explosions whenever the gas may again accumulate to the proper degree. Such a predicament is not uncommon, and it is one against which no human skill can guard. Yet even here, the sense of duty, and the hope of saving some workmen from a lingering death by wounds or suffocation, lead this intrepid class of men to descend amid the very demons of the mine.

As soon as the ventilation is restored by temporary brattices, the stoppings and doors are rebuilt in a substantial manner, and the workings are resumed with the wonted activity. From an inspection of *fig. 1122.*, p. 420. it is obvious that the stability of the main stopping *p*, is an important point; for which reason it is counterforted by strong walls of stone, to resist the explosive force of fire-damp.

When it is known that fire exists in the wastes, either by the burning of the small coal-dust along the roads, or from the ignition of the solid coal by a blower of gas, the inspection of the mine is incomparably more hazardous, as safety cannot be insured for an instant; for if the extrication of gas be great, it rapidly accumulates, and whenever it reaches the place where the fire exists, a new explosion takes place. There have been examples of the most furious detonations occurring regularly after the interval of about an hour, and being thus repeated 36 times in less than two days, each eruption appearing at the pit mouth like the blast of a volcano. It would be madness for any one to attempt a descent in such circumstances. The only resource is to moist up the pit, and check the combustion by exclusion of atmospheric air, or to drown the workings by letting the water accumulate below ground.

When fire exists in the wastes, with less apparent risk of life, water is driven upon it by portable fire-extinguishing engines, or small cannon are discharged near the burning coal, and the concussion thus produced in the air sometimes helps to extinguish the flame.

Since the primary cause of these tremendous catastrophes is the accession of the explosive gases by the candle of the miner, it has been long a desideratum to procure light of such a nature as may not possess the power of kindling the fire-damp. The train of light producible from the friction of flint and steel, by a mechanism called

a *steel mill*, has been long known, and afforded a tolerable gleam, with which the miners were obliged to content themselves in hazardous atmospheres.

It consists of a small frame of iron, mounted with a wheel and pinion, which give rapid rotation to a disk of hard steel placed upright, to whose edge a piece of flint is applied. The use of this machine entailed on the miner the expense of an attendant, called the miller, who gave him light. Nor was the light altogether safe, for occasionally the ignited shower of steel particles attained to a sufficient heat to set fire to the fire-damp.

At length the attention of the scientific world was powerfully attracted to the means of lighting the miner with safety, by an awful catastrophe which happened at Felling Colliery, near Newcastle, on the 25th May, 1812. This mine was working with great vigour, under a well-regulated system of ventilation, set in action by a furnace and air-tube, placed over a rise-pit in elevated ground. The depth of winning was above 100 fathoms; 25 acres of coal had been excavated, and one pit was yielding at the rate of 1700 tons per week. At 11 o'clock in the forenoon the night shift of miners was relieved by the day shift; 121 persons were in the mine, at their several stations, when, at half-past 11, the gas fired, with a most awful explosion, which alarmed all the neighbouring villages. The subterraneous fire broke forth with two heavy discharges from the dip-pit, and these were instantly followed by one from the rise-pit. A slight trembling, as from an earthquake, was felt for about half a mile round the colliery, and the noise of the explosion, though dull, was heard at from 3 to 4 miles' distance. Immense quantities of dust and small coal accompanied these blasts, and rose high into the air, in the form of an inverted cone. The heaviest part of the ejected matter, such as corves, wood, and small coal, fell near the pits; but the dust borne away by a strong west wind fell in a continuous shower a mile and a half from the pit. In the adjoining village of Heworth it caused a darkness like that of early twilight, covering the roads where it fell so thickly that the footsteps of passengers were imprinted in it. The heads of both shaft-frames were blown off, their sides set on fire, and their pulleys shattered to pieces. The coal-dust ejected from the rise-pit into the horizontal part of the ventilating tube, was about 3 inches thick, and speedily burnt to a cinder; pieces of burning coal, driven off the solid stratum of the mine, were also blown out of this shaft. Of the 121 persons in the mine at the time of the explosion, only 32 were drawn up the pit alive, 3 of whom died a few hours after the accident. Thus no less than 92 valuable lives were instantaneously destroyed by this pestilential fire-damp. The scene of distress among the relatives at the pit mouth was indescribably sorrowful.

Dr. W. Reid Clanny, of Sunderland, was the first to contrive a lamp which might burn among explosive air without communicating flame to the gas in which it was plunged. This he effected, in 1813, by means of an air-tight lamp, with a glass front, the flame of which was supported by blowing fresh air from a small pair of bellows through a stratum of water in the bottom of the lamp, while the heated air passed out through water by a recurved tube at top. By this means the air within the lamp was completely insulated from the surrounding atmosphere. This lamp was the first ever taken into a body of inflammable air in a coal-mine, at the exploding point, without setting fire to the gas around it. Dr. Clanny made another lamp upon an improved plan, by introducing into it the steam of water generated in a small vessel at the top of the lamp, heated by the flame. The chief objection to these lamps is their inconvenience in use.

Various other schemes of safe-lamps were offered to the miner by ingenious mechanicians, but they have been all superseded by the admirable invention of Sir H. Davy, founded on his fine researches upon flame. The lamp of Davy was instantly tried and approved of by Mr. Buddle and the principal mining engineers of the Newcastle district. A perfect security of accident is therefore afforded to the miner in the use of a lamp which transmits its light, and is fed with air, through a cylinder of wire gauze; and this invention has the advantage of requiring no machinery, no philosophical knowledge to direct its use, and is made at a very cheap rate.

In the course of a long and laborious investigation on the properties of the fire-damp, and the nature and communication of flame, Sir H. Davy ascertained that the explosions of inflammable gases were incapable of being passed through long narrow metallic tubes; and that this principle of security was still obtained by diminishing their length and diameter at the same time, and likewise diminishing their length, and increasing their number, so that a great number of small apertures would not pass an explosion, when their depth was equal to their diameter. This fact led him to trials upon sieves made of wire-gauze, or metallic plates perforated with numerous small holes; and he found it was impossible to pass explosions through them.

The apertures in the gauze should never be more than 1-20th of an inch square. In the working models sent by Sir H. to the mines, there were 748 apertures in the square inch, and the wire was about the 40th of an inch diameter. The cage or cylinder of wire gauze should be made by double joinings, the gauze being folded over in such a manner as to leave no apertures. It should not be more than two inches in diameter; or in large cylinders the combustion of the fire-damp renders the top inconveniently

hot; and a double top is always a proper precaution, fixed at a distance of about half an inch above the first top. The gauze cylinder should be fastened to the lamp by a screw of 4 or 5 turns. All joinings in the lamp should be made with hard solder; and the security depends upon the condition, that no aperture exists in the apparatus larger than in the wire gauze.

The forms of the lamp and cage, and the mode of burning the wick, may be greatly diversified; but the principle which ensures their safety must be strictly attended to. See LAMP OF DAVY, SAFETY LAMP, and VENTILATION.

The state of the air in coal mines, from very early periods till the discovery of the safe-lamp, was judged of by the appearances exhibited by the flame of a candle; and this test must in many circumstances be still had recourse to. When there is merely a defect of atmospheric oxygen, the air being also partially vitiated by a little carbonic acid, either from choke-damp or the lungs and candles of the miners, the lights burn with a very dull flame, the tallow ceases to melt in the cup formed round the wick, till the flame flickers and expires. In this case the candle may be kept burning by slanting it more or less towards a horizontal position, which causes the tallow to melt with the edge of the flame. The candle is thus rapidly wasted, however; and therefore an oil lamp is preferable, as it continues to burn where a candle would be extinguished. The candles of the collier are generally small, with a very small wick; such being found to produce a more distinct flame than candles of a large size with a thick wick.

In trying the quality of the air by the flame of a candle, the wick must be trimmed by taking off the snuff, so as to produce a clear, distinct, and steady-burning flame. When a candle thus trimmed is looked at in common air, a distinct and well-defined cone of flame is seen, of a fine sky-blue at the bottom next the wick, and thence of a bright yellow to the apex of the cone. Besides this appearance, there is another, surrounding the cone, which the brightness of the flame prevents the eye from discerning. This may be seen by placing one of the hands expanded as a screen betwixt the eyes and the candle, and at the distance of about an inch, so that the least point of the apex of the yellow flame may be seen, and no more. By this method, a top, as the miners term it, will be distinctly observed close to the apex of the yellow flame, from an eighth to a quarter of an inch in length. This top is of a yellowish-brown colour, and like a misty haze. This haze is seen not only on the top, but it extends downwards and surrounds the flame fully half way, about a twentieth of an inch in thickness; here it assumes a violet colour, which passes into a beautiful blue at the bottom next the wick. The test of the state of the air in mines, or "trying the candle," as practised by miners, depends entirely on the appearance which this haze assumes in shape and colour at the top of the flame. In fact, this top has distinct appearances when burning in atmospheric air, carbonated air, azotized air, or fire-damp air; displaying many modifications, according to the proportions of the various admixtures.

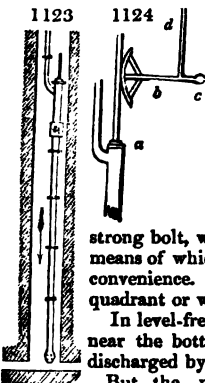
When azote or carbonic acid abounds, the top is frequently an inch or two in length, of a decided brown colour, and the flame is short and dim. When they are still more copious, the flame goes out, and the miners immediately retire.

When inflammable air is imagined to exist in considerable quantity, the miner trims his candle, and advances with cautious step, holding the candle with the left hand, and screening the flame with the right; and as the fire-damp floats in the upper part of the gallery next the roof, he holds the candle as low as he can, and keeping his eye fixed on the tip, he moves forwards. If the gas be small in quantity, he may reach the forehead without observing any material change in his light. But if in his advance he perceives the tip to elongate, and take a bluish-gray colour, he is put on his guard, and steps on with much caution; and if the tip begins to spire, he drops down on one knee, and holding the candle near the pavement, gradually raises it up, and watches the change it undergoes as it approaches the roof. If the gas be copious, the flame elongates into a sharp spire, as well as the top. It is in general reckoned dangerous when the tip changes from the bluish-gray to a fine blue colour, accompanied with minute luminous points, which pass rapidly upwards through the flame and top. When the symptoms are manifestly dangerous, a sudden movement of the hands or body is liable to produce ignition by agitation of the fire-damp. The experienced miner therefore slowly and cautiously lowers his candle to the pavement, and then turning round, effects his retreat slowly, or slips up his right hand and extinguishes the flame with his finger and thumb. Should he venture too far, and approach the body of gas in an explosive condition, the tip of the candle rapidly elongates, and the whole rises in a sharp spire several inches in length; and then the whole surrounding atmosphere is in a blaze, an explosion ensues, and destructive ravage is the consequence, to an extent proportioned to the quantity of fire-damp. See VENTILATION.

This *trying the candle* is a delicate operation, requiring much practical sagacity, where the lives of so many men, and the welfare of the whole establishment, are at stake. Almost every colliery, after having been worked for some time, gives a peculiar top to

the candle; so that while in one mine liable to fire-damp an explosion will take place with a top less than an inch long, in another mine the top may be two inches high, and yet the air be considerably under the point of accension. These differences depend on several particulars. If the gas has not passed through a long course of ventilation, and is little mixed with air, it will ignite with a very short top; while on the other hand, a gas which has run through a ventilation of 20 or 30 miles may cause the production of a long top without hazard. It is hence obvious, that skilful experience, and thorough practical knowledge, are the only sure guides in these cases.

We shall now describe briefly the modern modes of working coals a-dipping of, and deeper than, the engine-pit bottom. One of these consists in laying a working pump barrel with a long wind-bore at the bottom of the downset mine, furnished with a smooth rod working through a collar at the top of the working barrel. At one side of this, near the top, a kneed pipe is attached, and from it pipes are carried to the point of delivery, either at the engine-pit bottom or day level, as represented in *fig. 1123*. The spears are worked sometimes by rods connected with the machinery at the surface;

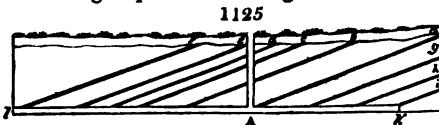


in which case the spears, if very long, are either suspended from swing or pendulum rods, or move on friction rollers. But since the action of the spears, running with great velocity the total length of the engine stroke, very soon tears every thing to pieces, the motion of the spears underground has been reduced from 6 or 8 feet, the length of the engine stroke, to about 15 inches; and the due speed in the pump is effected by the centering of a beam, and the attachment of the spears to it, as represented in *fig. 1124*, where *a* is the working barrel, *b* the beam centered at *c*, having an arc-head and martingale sinking-chain. The spears *d* are fastened by a strong bolt, which passes through the beam; and there are several holes, by means of which the stroke in the pumps can be lengthened or shortened at convenience. The movement of the spears is regulated by a strong iron quadrant or wheel at the bottom.

In level-free coals, these pumps may be worked by a water-wheel, stationed near the bottom of the pit, impelled by water falling down the shaft, to be discharged by the level to the day (day-level).

But the preferable plan of working under-dip coal, is that recently adopted by the Newcastle engineers; and consists in running a mine a-dipping of the engine-pit, in such direction of the dip as is most convenient; and both coals and water are brought up the rise of the coal by means of high-pressure engines, working with a power of from 30 to 50 pounds on the square inch. These machines are quite under command, and, producing much power in little space, they are the most applicable for underground work. An excavation is made for them in the strata above the coal, and the air used for the furnace under the boiler, is the returned air of the mine ventilation. In the dip-mine a double tram-road is laid; so that while a number of loaded corves are ascending, an equal number of empty ones are going down. Although this improved method has been introduced only a few years back, under-dip workings have been already executed more than an English mile under-dip of the engine-pit bottom, by means of three of these high-pressure engines, placed at equal distances in the under-dip mine. It may hence be inferred, that this mode of working is susceptible of most extensive application; and in place of sinking pits of excessive depth upon the dip of the coal, at an almost ruinous expense, much of the under-dip coal will in future be worked by means of the actual engine-pits. In the Newcastle district, coals are now working in an engine-pit 115 fathoms deep under-dip of the engine-pit bottom, above 1600 yards, and fully 80 fathoms of perpendicular depth more than the bottom of the pit.

If an engine-pit be sunk to a given coal at a certain depth, all the other coals of the



coal-field, both above and below the coal sunk to, can be drained and worked to the same depth, by driving a level cross-cut mine, both to the dip and rise, till all the coals are intersected, as represented *fig. 1125*.

where *a* is the engine-pit bottom reaching to the coal *a*; and *b*, *c*, *d*, *e*, *f*, coals lying above the coal *a*; the coals which lie below it, *g*, *h*, *i*; *k* is the forehead of the cross-cut mine, intersecting all the lower coals; and *l*, the other forehead of the mine, intersecting all the upper coals.

In the "Report from the select committee of the House of Lords, appointed to take into consideration the state of the coal trade in the United Kingdom," printed in June, 1829, under the head of Mr. Buddle's evidence we have an excellent description of the

nature and progress of creeps, which we have adverted to in the preceding account. The annexed *fig. 1126.* exhibits the creep in all its progressive stages, from its commencement until it has completely closed all the workings, and crushed the pillars of coal. The section of the figures supposes us standing on the level of the different galleries which are opened in the seam. The black is the coal pillars between each gallery; when these are weakened too much, or, in other words, when their bases become too narrow for the pavement below, by the pressure of the incumbent stratification, they sink down into the pavement, and the first appearance is a little curvature in the bottom of each gallery: that is the first symptom obvious to sight; but it may generally be heard before it is seen. The next stage is when the pavement begins to open with a crack longitudinally. The next stage is when that crack is completed, and it assumes the shape of a metal ridge. The next is when the metal ridge reaches the roof. The next stage is when the peak of the metal ridge becomes flattened by pressure, and forced into a horizontal direction, and becomes quite close; just at this moment the coal pillars begin to sustain part of the pressure. The next is when the coal pillars take part of the pressure. The last stage is when it is dead and settled; that is, when the metal or factitious ridge, formed by the sinking of the pillar into the pavement, bears, in common with the pillars of coal on each side, the full pressure, and the coal becomes crushed or cracked, and can be no longer worked, except by a very expensive and dangerous process. *Fig. 1126.*



1. First stage of active creep.
2. Second do.
3. Third do.
4. Fourth do.

5. The metal ridge closed, and the creep beginning to settle.
6. The creep settled, the metal ridges being closely compressed, and supporting the roof.

The quantity of coals, cinders, and culm shipped coastwise, and exported from the several parts of the United Kingdom in the year 1837, was 8,204,301 tons; in 1836, the quantity was 7,389,272 tons, being an increase of 815,029 tons, or 11·03 per cent. in favour of 1837.

The following TABLE shows the separate proportions of this quantity supplied by England and Wales, Scotland, and Ireland:—

| | 1836. | 1837. | Increase. |
|-------------------|--------------------|--------------------|-------------------------------------|
| England and Wales | Tons. 6,757,937 | Tons. 7,570,254 | Tons. 812,317 or 12·02 per cent. |
| Scotland | - - - 624,308 | - - - 626,532 | - - - 2,204 0·36 |
| Ireland | - - - 7,027 | - - - 7,515 | - - - 488 6·94 |
| Total | - - - 7,389,272 | - - - 8,204,301 | - - - 815,029 or 11·03 per cent |

PITCOAL, ANALYSIS OF. The greater part of the analyses of coals hitherto published have been confined to the proportions of carbon, hydrogen, and oxygen, to the neglect of the sulphur, which exists in many coals to a degree unwholesome for their domestic use, pernicious for the smelting of iron, and detrimental to the production of gas; since the sulphuretted hydrogen produced requires so much washing and purification as at the same time to impoverish the light by condensing much of the olefiant gas, its most luminiferous constituent. In the numerous reports upon the composition of coals which I have been professionally called upon to make, I have always sought to determine the proportion of sulphur, which may be done readily to one part in a thousand; as also, that of combustible gaseous matter, of coke, and of incombustible ashes.

The following coals have been found to be of excellent quality, as containing very little sulphur, seldom much above 1 per cent., and little incombustible matter,—hence well adapted as fuel, whether for steam navigation, for iron smelting, for household consumption, or for gas, according to their relative proportions of carbon and hydrogen; a relative excess of carbon constituting a coal best adapted for furnaces of various kinds, while a relative excess of hydrogen forms the best coal for the common grates and gas works.

1. *Mr. Powell's Duffy or Steam Coal.* — Specific gravity, 1·32; ashes, per cent., 2·6;

gaseous products in a luted crucible, 14; brilliant coke, 86: not more than 1 per cent. of sulphur; while many of the Newcastle coals contain from 4 to 6, and others which I have examined from 8 to 10 of the same noxious constituent; and which is a less powerful calorific constituent than hydrogen and carbon.

2. *The Blackley Hurst Coal of Lancashire.*—Specific gravity, 1.26; ashes per cent., 1.2; combustible gases, 41.5; coke, 58.5; sulphur 1. Another specimen had a specific gravity of 1.244; 2 per cent. of ashes; 38.5 of combustible gases; 1 of sulphur. This is a very good coal for gas, and for domestic use.

3. *The Varley Rock Vein Coal*, near Pontypool; shipped by Mr. John Vipond.—Specific gravity, 1.296; ashes (whitish) 5 per cent.; 32 of combustible gases; 68 of coke. Sulphur from 2 to 3 per cent. A good household coal.

4. *The Llangennech Coal* has a well-established reputation for the production of steam, and is much employed by the British government for steam navigation, as well as at Meux's, and others of the great breweries in London. It affords a very intense heat, with little or no smoke; and sufficiently diffusive, for extending along the flues of the boilers; whereas the anthracite coal, containing very little hydrogen, yields, in common circumstances, a heat too much concentrated under the bottom of the boilers, and acting too little upon their sides. Specific gravity, 1.337; intermediate between that of the Newcastle and the anthracite. Ashes per cent. from 3 to 3.5; combustible gases, 17; coke 83; sulphur, only *one half* per cent. It is therefore a pure and very powerful fuel.

I have examined many coals with my calorimeter; of which some account is given under *FURT*.

It is quite susceptible of positive proof that, by no arrangement yet discovered, can more than two-thirds of the heat generated by a given quantity of coal, during combustion, be fairly absorbed and utilised in any of our manufactories; and, moreover, there are undeniable facts, which demonstrate that seldom, in the burning of coal, are more than three-fourths of the total heat, which might be eliminated, actually obtained, thus justifying the supposition, that one half of all the coal now consumed, is virtually wasted, and lost to society. The first of these defects, or the non-absorption of heat by the various objects exposed to the action of fire, has pretty largely attracted the attention of inventors; and, within the last twenty years, several very satisfactory improvements have been produced, especially with reference to steam-boilers. For the most part these improvements have consisted in lengthening the flues, and exposing a larger surface of the boiler to the action of the heated air passing from the furnace to the chimney. From this arrangement, a vast economy of fuel has resulted, and particularly from that form of setting, known under the term "Cornish boiler setting." But there is yet a point in this matter which requires careful investigation, and that is the extent to which the current or draught, in such flues, ought to be retarded, so as to favour the transmission of heat from the flue to the interior of the boiler. Remembering that air is an extremely bad conductor of heat, and that water about to become converted into steam is also a bad conductor, it is evident that time must form an important element in the perfect transmission of heat from one of these to the other; and hence, with a great velocity of current existing in the flues, very little heat would pass from air, however high its temperature, to water contained in a boiler, and so circumstanced in respect to its all but gaseous condition. As an illustration of this line of argument, we may adduce the case of gunpowder, which, although forming a most intense heat, by its combustion, scarcely warms the barrel of a gun, through which it rushes during an explosion. Here the barrel of the gun may be said to represent the flue, the force of the explosion the draught, and the gaseous products of the gunpowder those of an ordinary fire during combustion; yet the rapidity with which the heated air passes is so great, that the whole calorific effect is lost, and, as it were, thrown into the chimney.

In corroboration of these views we may direct attention to the results of some experiments on fuel made at the Museum of Practical Geology by Sir H. de la Beche and Dr. L. Playfair, and which clearly show that, to open the damper of a steam-boiler furnace is pretty generally to diminish the effective power of the fuel: there can, in fact, be no doubt that great waste of coal now arises from inattention to this simple circumstance; and that much of the heat of the fire, which ought to go to the boiler, is lost by its hasty transmission to the chimney. If, however, there be thus far room for improvement in the direction just indicated, still wider is the vacant space, caused by imperfect combustion, or, in technical phrase, "bad stoking." We cannot sufficiently insist upon the necessity for some speedy and judicious alterations in this matter; and, to be really useful, these alterations should either supersede the employment of a stoker altogether, or render negligence on his part capable of immediate and certain detection. If the combustible constituents of common coal be regarded as composed solely of hydrogen and carbon, and the heating power of hydrogen be, as is represented, three times greater than that of carbon, no reasonable being can fail to perceive the enormous

fully of permitting any portion of the hydrogenous constituent of coal to escape from the furnace unburnt; for its loss implies the waste of three times its weight of the solid or carbonaceous constituent. Nevertheless, so uniform and systematic has the waste of hydrogen become, from the prevalence of bad stoking, that several eminent engineers, unacquainted with the real facts of the case, have come to regard the calorific value of a coal as proportioned only to the carbon it contains; thus attributing no heating power whatever to the hydrogen; and this too in the face of the circumstance, that the common gas of our streets is largely used for cooking purposes, and yields, weight for weight, more than double the quantity of heat given out by either coke or charcoal! As usually employed, fully one half of the hydrogen of bituminous coal passes unconsumed up the chimney, merely because the stoker, to economize his labour, and avoid trouble, throws on to the bars of his furnace a thick layer of fuel; by which loss is caused in two or three directions. In the first place, as no atmospheric air can force its way through the heap, a process of distillation takes place from the upper surface of the carbonaceous mass, exactly as happens in a gas retort; and when the whole of the volatile matters have been thus driven off, and not before, the residuary cinder or coke enters into combustion. No wonder, then, that practical men have arrived at the conclusion, that this coke fairly represents the value of the coal; for, as we have seen, combustion begins only when nothing else is left. But the loss of the hydrogen is not the only waste consequent upon throwing too much coal at once upon the fire-bars. Dr. Kennedy long ago proved that the hottest part of a furnace is about one inch above the fire-bars, for there perfect combustion goes on, and the carbon consumed is converted into carbonic acid, with the total evolution of all its heat. But, let us imagine a mass of red-hot coke or cinder, two or three inches thick, lying above the carbonic acid thus produced, and through which, consequently, it must pass, to communicate its heat to the boiler or chimney. In passing over this red-hot coke, the carbonic acid would be converted into carbonic oxide, and thus not only remove a quantity of carbon equal to its own, without yielding any additional heat, but actually with the production of cold, or, in other words, the absorption of heat; for the volume of carbonic oxide, engendered in this manner, is double of that of the carbonic acid originally formed; and hence this expansion must be accompanied by the disappearance of heat, which becomes latent in the carbonic oxide. Here then are three distinct sources of waste, consequent upon this single mal-practice, which however entails, as a necessary sequence, the production of loss from a different cause. As by heaping a large quantity of fuel upon the furnace-bars, a stoker is enabled to neglect, with impunity, his duty for many minutes, so it frequently happens that this neglect is continued until portions of the fire-bars, becoming uncovered with fuel, permit the ingress of cold air in a large quantity through these openings; and thus not only is the combustion of the remaining coal retarded by this mis-direction of the draught, but the aggregate temperature of the whole furnace is vastly diminished. Now, we can scarcely conceive a more tempting or a more promising field of inquiry than is opened out in the great question, How are these evils to be effectually got rid of? Thousands of individuals in this country have the means daily in their hands of making practical experiments upon this subject; but they are not, perhaps, even aware that such evils exist. Let us hope then that some few of these persons may be roused into a state of useful activity, and that the advent of another Exhibition may be preceded by some invention, capable of counteracting this great national loss. It is, beyond all others, a problem within the domain of the humblest working man. Before quitting the article coal, we feel that a few observations on the present modes of estimating the value of that substance, in a commercial point of view, are called for.

In the investigation undertaken at the Museum of Economic Geology, three different methods have been adopted: the whole of which, judging by the result, seem defective and worthless. The experiments were meant to have special reference to the boilers of marine engines, yet those made have been upon a Cornish boiler, set after the Cornish fashion. Independently, therefore, of the fact that the results thus obtained are, to the last degree, unsatisfactory and discrepant, they furnish no guide by which to judge of the effects that might follow when a marine boiler is used. Of the two other methods, the one consists in making an ultimate analysis of the coal by peroxide of copper; the other by the quantity of litharge capable of being reduced by a given weight of the coal. Both of these processes seem to have been conducted on by far too small a quantity of matter to yield a result worthy of confidence; for but $3\frac{1}{2}$ grains of coal were taken, on an average, for ultimate analysis, and only 5 grains for the litharge assay. The errors of manipulation are, therefore, relatively excessive; and, as a consequent result, we find these methods contradicting each other to something like 15 or 16 per cent.,—as a careful examination of the parliamentary report will prove. For the sake of illustration we select, at random, from samples of coal thus treated, merely premising that the amount of lead produced from the ultimate analysis was found by estimating the atoms of lead, carbon, oxygen, and hydrogen, respectively, at the numbers 104, 6, 8, and 1.

Thus calculated, we have the following discordant figures given by the two methods in question, which, it is needless to say, present differences greater than can possibly exist between any two kinds of coal whatever :—

| | | By Litharge. | By Analysis. | Difference. |
|------------------|------------------|--------------|--------------|-------------|
| Newcastle coals. | Bates' Hartley - | - 144·6 | 162·8 | 18·2 |
| | Hastings' do. - | - 142·8 | 166·4 | 23·6 |
| Welsh coal. | Lynvi - | - 161·2 | 175·8 | 14·6 |
| Lancashire coal. | Laffak - | - 134·4 | 163·8 | 29·4 |

Thus Bates' Hartley, which by the litharge assay is better than the Hastings' Hartley and Laffak, turns out, from the ultimate analysis, worse than either of them. We deem it useless to pursue this subject further, enough having been shown to prove the utter inadequacy of the means now employed for ascertaining the calorific value of coal. The most likely method of effecting this object would be to burn a given weight of each coal in a vessel filled with pure oxygen gas, and surrounded by a large body of cold water; ignition being commenced by a fine platinum wire, heated through the agency of a galvanic battery. Some experiments made in this way, for a special purpose, have given the most uniform and satisfactory results.

The only manufactured articles made from coal are coke and coal-gas. The burning of coke resolves itself into two objects; and, as neither of these are gained by gas manufacturers, it becomes necessary to distinguish between what is called gas-coke and oven-coke. The word coke applies, properly, to the latter alone; for in a manufacturing sense, the former is merely cinder. The production of good coke requires a combination of qualities in coal not very frequently met with; and hence first-rate coking coals can be procured only from certain districts. The essential requisites are, first, the presence of very little earthy or incombustible ash; and, secondly, the more or less infusibility of that ash. The presence of any of the salts of lime is above all objectionable, after which may be classed silica and alumina; for the whole of these have a strong tendency to produce a vitrification, or slag, upon the bars of the furnaces in which the coke is burnt; and in this way the bars are speedily corroded or burnt out; whilst the resulting clinker impedes or destroys the draught, by fusing over the interstices of the bars or air passages. Iron pyrites is a common—but, except in large quantities, not a very serious—obstacle to the coke maker: for it is found in practice, that a protracted application of heat in the oven dissipates the whole of the sulphur from the iron, with the production of bisulphuret of carbon and metallic carburet of iron,—the latter of which alone remains in the coke, and, unless silica be present, has no great disposition to vitrify after oxidation. One object, therefore, gained by the oven coke manufacturer over the gas maker, is the expulsion of the sulphuret of carbon, and consequent purification of the residuary coke. Another, and a still more important consequence of a long sustained and high heat is, the condensation and contraction of the coke into a smaller volume, which, therefore, permits the introduction of a much greater weight into the same space; an advantage of vast importance in blast furnaces, and, above all, in locomotive engines, as the repeated introduction of fresh charges of cold fuel is thus prevented. Part of this condensation is due to the weight of the superincumbent mass of coal thrown into the coke oven, by which (when the coal first begins to cake or fuse together) the particles are forced towards each other, and the cavernous character of cinder got rid of: but the chief contraction arises, as we have said, from the natural quality of carbon, which, like alumina, goes on contracting, the longer and higher the heat to which it is exposed. Hence, good coke cannot be made in a short time, and that used in locomotive engines is commonly from 48 to 96, or even 120 hours in the process of manufacture.

The prospects of improvement in coke-making seem not very great, and point rather to alterations in the oven than in the process; nor does it seem possible to utilize the heat evolved by the gaseous constituents of the coal; for this heat, though large in quantity, is of trifling intensity, and, consequently, admits of but a restricted use in the arts; moreover, the incessant variations to which it is subject, according to the period of manufacture, still further interfere with its employment, even where great intensity of fire is not needed, as in steam boilers, for example. Nevertheless, there appears no valid reason why sets of coke ovens might not be so arranged as mutually to compensate for each other, and produce upon one particular flue a constant and uniform effect. Contrivances of this kind have been projected,—but hitherto, we may suppose, without success, as our largest coke makers still continue the old mode of working.

The process of gas making from coal is in itself so large and singular an operation, and has, besides, such a variety of connections with other branches of industry, that, though its details and possible improvements might very correctly follow upon an analysis of the coke maker's art, yet we prefer to treat of it amongst the more advanced and scientific manufactures, rather than associate its comprehensive traits of civilized skill with the rough and ready exigencies of "raw material" incidental to this early stage of our

program. We feel, too, that the introduction of such a subject here would, in some degree, break the geological connection which exists between coal and iron, — a connection, by the bye, equally remarkable in a mercantile aspect.

An account of the nature and extent of the various deposits of mineral fuel in various parts of the world. Accompanied by a map showing the extent and position of the principal coal fields of Europe and North America. By D. T. Ansted, M. A., F. R. S. &c., Prof. Geol., K. C. L. *General account of materials used for fuel*—The chief supplies of valuable fuel are, and always have been, derived immediately or distantly from the vegetable kingdom. Whether in the form of wood, peat, lignite, or coal of various kinds, the original substance of all fuel has been found to have this origin, and thus it would seem that the power of vitality exerted in producing woody fibre has been from time to time stored up, as it were, into vast reservoirs where it might be preserved safely and permanently for an indefinite period.

In warm climates, where the growth of vegetation is extremely rapid and comparatively little fuel is needed, or in early periods of civilization before men congregate in large masses in towns, or are actively employed in manufacture, there is little need of more fuel than is supplied by the natural growth of forests; but under other circumstances where forests are gradually removed, and the consumption of fuel at the same time increases, the reserved stores are greatly needed and must ultimately be reckoned among the main sources of a country's wealth. The accumulations of mineral fuel in the British islands may be ranked as one of those natural advantages without which our country could not possibly have taken up and held for a long time the position she occupies among the nations of the earth: and thus, as one of the great and principal sources of its mineral treasure, the coal deposits of England demand and deserve our careful attention. The relative supply of other countries, and the activity and energy displayed in taking advantage of the existence of mineral fuel, must also be worthy of attention, as illustrating and explaining the condition of many manufactures, and probable advance of the inhabitants of such districts in the refinements of civilization. Since the introduction of steam power for all purposes of machinery, the consumption of coal has very greatly increased, and at present it would be difficult to set any limits to the use of so valuable a material.

The changes undergone by vegetable matter when buried in the earth, and accumulated in large quantities, and the length of time needed to produce any marked alteration, are subjects rather more interesting, it may seem, to the chemist than to the practical man, who looks only for fuel that he may employ economically. But inasmuch as the real condition of coal varies considerably, and different kinds are valuable for different purposes, it is desirable that the whole history of coal and lignite beds, and of peat and turf, should be generally understood by any one using any or all of these substances extensively.

Vegetable matter consists of particles of carbon with minute proportions of several other elements arranged round minute cavities or cells, many of these being mechanically connected to form the varieties of vegetable fibre. A large quantity of water is also present, and so long as the vegetable lives, there is a constant change and circulation of material particles kept up replacing and renewing the different portions. When death takes place, there is a tendency to decomposition, or the separation of the whole into minute atoms having no further relation to each other. But this is frequently checked by various conditions, such as the presence of some substances derived from plants themselves, or the absence of sufficient oxygen gas to allow the change to take place by mixing with the carbon and becoming carbonic acid gas, the first step in the process of destruction. These causes act constantly but partially, and thus a large quantity of vegetable matter is always in the course of decomposition, while in particular spots a large quantity is constantly being accumulated. The latter condition is seen in our climate in the gradual but steady increase of peat bogs. The former is too common to require further notice.

2. *Peat and Turf.*—Accumulations of vegetable matter may be chiefly composed either of succulent vegetation, grasses, or marsh plants, or of trees, and the structure and condition of woody fibre is well known to be very different from that of grasses and succulent plants. There are thus two very distinct kinds of material preserved, the one undergoing change much less rapidly than the other, and perhaps much less completely. It is easily proved that from the accumulation of forest trees has been obtained the imperfect coal called lignite, while from marsh plants and grasses mixed occasionally with wood we obtain peat turf and bog. All these substances consist to a great extent of carbon, the proportions amounting to from 50 to 60 per cent., and being generally greater in lignite than in turf. On the other hand, the proportion of oxygen gas is generally very much greater in turf than in lignite. The proportion of ash is too variable to be worth recording, but is generally sufficiently large to injure the quality of the fuel.

As a very large quantity of turf exists in Ireland, covering, indeed, as much as one seventh part of the island, the usual and important practical condition of this substance can be best illustrated by a reference to that country. This will be understood by the following account of its origin, abstracted from the "Bog Report" of Mr. Nimmo. He says, referring to cases where clay spread over gravel has produced a kind of puddle preventing the escape of waters of floods or springs, and when muddy pools have thus been formed, that aquatic plants have gradually crept in from the borders of the pool towards their deep centre. Mud accumulated round their roots and stalks, and a spongy semi-fluid was thus formed, well fitted for the growth of moss, which now especially spears *Sphagnum* began to luxuriate; this absorbing a large quantity of water, and continuing to shoot out new plants above, while the old were decaying, rotting and compressing into a solid substance below, gradually replaced the water by a mass of vegetable matter. In this manner the marsh might be filled up while the central or moister portion, continuing to excite a more rapid growth of the moss, it would be gradually raised above the edges, until the whole surface had attained an elevation sufficient to discharge the surface water by existing channels of drainage, and calculated by its slope to facilitate their passage, when a limit would be, in some degree, set to its further increase. Springs existing under the bog or in its immediate vicinity, might indeed still favour its growth, though in a decreasing ratio; and here if the water proceeding from them were so obstructed as to accumulate at its base, and to keep it in a rotten fluid state, the surface of the bog might be ultimately so raised, and its continuity below so totally destroyed, as to cause it to flow over the retaining obstacle and flood the adjacent country. In mountain districts the progress of the phenomenon is similar. Pools indeed cannot in so many instances be formed, the steep slopes facilitating drainage, but the clouds and mists resting on the summits and sides of mountains, amply supply their surface with moisture, which comes, too, in the most favourable form for vegetation, not in a sudden torrent, but unceasingly and gently drop by drop. The extent of such bogs is also affected by the nature of the rocks below them. On quartz they are shallow and small; on any rock yielding by its decomposition a clayey coating they are considerable; the thickness of the bog (for example in Knocklaid in the county of Antrim, which is 168 feet high), being nearly 19 feet. The summit bogs of high mountains are distinguishable from those of lower levels by the total absence of large trees.

As turf includes a mass of plants in different stages of decomposition, its aspect and constitution vary very much. Near the surface it is light-coloured, spongy, and contains the vegetable matter but little altered; deeper, it is brown, denser, and more decomposed; and finally at the base of the greater bogs, some of which present a depth of 40 feet, the mass of turf assumes the black colour and nearly the density of coal, to which also it approximates very much in chemical composition. The amount of ash contained in turf is also variable, and appears to increase in proportion as we descend. Thus, in the section of a bog 40 feet deep at Tunahoe, those portions near the surface contained $1\frac{1}{2}$ per cent. of ashes, the centre portions $3\frac{1}{2}$ per cent., whilst the lowest 4 feet of turf contained 19 per cent. of ashes. In the superficial layers, it may also be remarked, that the composition is nearly the same as that of wood, the vegetable material being lost, and in the lower we find the change into coal nearly complete. Notwithstanding these extreme variations, we may yet establish the ordinary constitution of turf, and with certainty enough for practical use, and on the average specimens of turf selected from various localities, the following results have been obtained:—

The calorific power of dry turf is about half that of coal; it yields, when ignited with lead, about 14 times its weight of lead. This power is however immensely diminished in ordinary use by the water which is allowed to remain in its texture, and of which the spongy character of its mass renders it very difficult to get rid of. There is nothing which requires more alteration, than the collection and preparation of turf; indeed, for practical purposes, this valuable fuel is absolutely spoiled as it is now prepared in Ireland. It is cut in a wet season of the year; whilst drying it is exposed to the weather; it hence is in reality not dried at all. It is very usual to find the turf of commerce containing one-fourth of its weight of water, although it then feels dry to the hand. But let us examine what effects the calorific power. One pound of pure dry turf will evaporate 6 lbs. of water; now, in 1 lb. of turf as usually found, there are $\frac{2}{3}$ lb. of dry turf, and $1\frac{1}{2}$ lbs. of water. The $\frac{2}{3}$ lb. can only evaporate $4\frac{1}{2}$ lbs. of water; but out of this it must first evaporate the $\frac{1}{2}$ lb. contained in its mass, and hence the water boiled away by such turf is reduced to $4\frac{1}{2}$ lbs. The loss is here 30 per cent., a proportion which makes all the difference between a good fuel and one almost unfit for use. When turf is dried in the air under cover it still retains one tenth of its weight of water, which reduces its calorific power 12 per cent., 1 lb. of such turf evaporating $5\frac{1}{2}$ lbs. of water. This effect is sufficient, however, for the great majority of objects; the further desiccation is too expensive, and too troublesome to be used, except in special cases.

The characteristic fault of turf as a fuel is its want of density, which renders it difficult to concentrate within a limited space the quantity of heat necessary for many operations. The manner of heating turf is indeed just the opposite to anthracite. The turf yields a vast body of volatile inflammable ingredients, which pass into the flues and chimney, and thus distribute the heat of combustion over a great space, whilst in no one point is the heat intense. Hence for all flaming fires turf is applicable, and in its application to boilers, it is peculiarly useful, as there is no liability to that burning away of the metal, which may arise from the local intensity of coke or coal. If it be required, it is quite possible, however, to obtain a very intense heat with turf.

The removal of porosity and elasticity of turf, so that it may assume the solidity of coal, has been the object of many who have proposed mechanical and other processes for the purpose. It has been found that the elasticity of the turf fibre presents great obstacles to compression, and the black turf, which is not fibrous, is of itself sufficiently dense.

Not merely may we utilize turf in its natural condition, or compressed or impregnated pitchy matter, but we may carbonize it, as we do wood, and prepare turf charcoal, the properties of which it is important to establish:— 1. By heating turf in close vessels; by this mode loss is avoided, but it is expensive, and there is no compensation in the distilled liquors, which do not contain acetic acid in any quantity. The tar is often small in proportion, hence the charcoal is the only valuable product. Its quantity varies from 30 to 40 per cent. of dry turf. The products of the distillation of 1,157 lbs. of turf were found by Blavier to be charcoal, 474 lbs., or 41 per cent; watery liquid 226 lbs., or 19·3 per cent.; gaseous matter 450 lbs., or 39 per cent.; and tar 7 lbs., or 6 per cent.; but the proportion of tar is variable, sometimes reaching 24·5 per cent., when the turf is coaked in close vessels.

The economical carbonization of turf is best carried on in heaps, in the same manner as that of wood. The sods must be regularly arranged, and laid as close as possible; they are the better for being large, 15 inches long, by 6 broad and 5 deep. The heaps built hemispherically should be smaller in size than the heaps of wood usually are. In general 5,000 or 6,000 large sods may go to the heap, which will thus contain 1,500 cubic feet. The mass must be allowed to heap more than is necessary for wood, and the process requires to be very carefully attended to, from the extreme combustibility of the charcoal. The quantity of charcoal, obtained in this mode of carbonization, is from 25 to 30 per cent. of the weight of dry turf.

For many industrial uses the charcoal so prepared is too light, as, generally speaking, it is only with fuel of considerable density, that the most intense heat can be produced, but by coking compressed turf, it has already been shown, that the resulting charcoal may attain a density of 1,040, which is far superior to wood charcoal, and even equal to that of the best coke made from coal. As to calorific effects, turf charcoal is about the same as coal cokes, and little inferior to wood charcoal.

It is peculiarly important, in the preparation of the charcoal from turf, that the material should be selected as free as possible from earthy impurities, for all such are concentrated in the coke, which may be thereby rendered of little comparative value. Hence, the coke from surface turf contains less than 10 per cent. of ash, whilst that of dense turf of the lower strata contains from 20 to 30 per cent. This latter quantity might altogether unfit it for practical purposes.

Nature and Distribution of Coal.— True coal is so little altered from its original vegetable condition as to have left scarcely any trace of its true history. It is generally, however, associated with sands and clays, exhibiting numerous fragments of the ancient vegetation that obtained at the time of its formation; but these fragments are so far removed in every respect, from the existing form of vegetation, as to afford little clue to the ancient condition of the earth in this respect. In coal all trace of true woody fibre has disappeared; the water originally present, and so injurious in the less altered forms of vegetable fuel, is entirely absent, or, if present at all, is so rather mechanically than chemically, while the water originally in the plant appears to have undergone decomposition, the hydrogen uniting with some part of the carbon, to form carburetted hydrogen gas often existing in the cells, and between the plates of the coal under considerable pressure, and the oxygen being almost entirely removed. The former vegetable has now become a mineral substance, and lies in vast beds of variable thickness, and overlaying each other to the extent sometimes of more than a hundred in a single district; such beds being regularly interstratified with deposits of sand and clay, and occupying a distinct geological position, being, with only a few exceptions, confined to rocks belonging to the newer part of the palaeozoic series.

Between the Arctic Circle and the Tropic of Cancer repose all the principal carboniferous formations of our planet. Some detached coal deposits, it is true, exist above and below these limits, but they appear, so far as we know, to be of limited extent. Many of these southern coal-fields are of doubtful geological age; a few are supposed

to approximate to the class of true coals, as they are commonly styled, others are decidedly of the brown coal and tertiary period, while the remainder belong to various intermediate ages, or possess peculiar characters which render them of doubtful geological origin.

The coals of Melville Island and Byam Martin's Island certainly appear to be of the true coal period. We know that coal exists at numerous intermediate points, from the 75th to the 25th degree of north latitude in America, and also that it is worked on the Sulado and Rio Grande rivers in Mexico for the use of the steamers.

Southward of the Tropic of Cancer the existence of coal corresponding with the European and American hard coal is somewhat uncertain. There seems to be none on the South American continent, unless it be at Ano Paser, which needs confirmation, or in the province of Santa Catharina in Brasil. On the African continent we have had vague accounts of coal in Ethiopia and at Mozambique, also at Madagascar, and quite recently we have had intelligence of large quantities of coal in the newly-ceded territory above Port Natal, on the eastern side of Africa, but we believe no geologist has examined these sites. In the Chinese and Burmese empires only brown coal appears to approach the Tropic, but true coal seems to exist in the northern provinces. Southward of the Asiatic continent we are uncertain of the exact character of the coal deposits, such as occur abundantly at Sumatra, Java, and Borneo, and neighbouring islands. Coal, however, exists in these islands, and is of a fair workable quality.

In New South Wales the great coal range on the eastern margin of that continent has sometimes been described as resembling the Newcastle coal in England, and sometimes it is described as of more ancient date. This coal differs essentially from that of any known European formation, but bears a strong resemblance to the Burdwan coal of India.

We have not yet arrived at the period when we could pronounce with any approach to certainty on the actual number of coal basins in the world; the total number must, however, amount at least to from 250 to 300 principal coal fields, and many of these are subdivided by the disturbed position of the strata into subordinate basins.

The basins or coal districts are, however, grouped into a comparatively small number of districts, and even many of these are little known and not at all measured. The greater number occur in Western Europe and Eastern North America, while Central and Southern Africa, South America, and a large part of Asia, are totally without any trace of true carboniferous rocks. The remarks, therefore, that will follow chiefly refer to our own and adjacent countries, or of the United States and British North America.

There are various kinds of coal obtained from mines worked in the true coal fields which may be grouped into bituminous, steam-coal, and anthracite. Of the first, the cannel is a remarkable variety, the coarser kinds of it being called in Scotland "parret," and sometimes splintcoal. It contains from 40 to nearly 60 per cent. of volatile matter, and the proportion of carbon varies within the same limits. It burns readily, taking fire like a candle, and giving a bright light and much smoke. The ash varies from 4 to 10 per cent. This coal yields on destructive distillation a very large quantity of gas, and is profitably used for that purpose. The gas is not only large in quantity but remarkably pure, and of excellent quality for purposes of illumination. There is a large quantity of this kind of coal in the Scotch coal-fields, and it has also been found in the Newcastle district, in the Wigan portion of the Lancashire coal-field, and in Yorkshire and Derbyshire coal-fields. America yields cannel coal in Kentucky, Indiana, Illinois, and Missouri. Cannel coal passes into jet, and may, like jet, be worked into various ornaments, but it is brittle and not very hard; the seams are generally rather thin, although there are several important exceptions in which the quantity is very considerable. The coal of Belgium from one basin (that of Mons) seems to be of this kind.

Another and far more abundant kind of bituminous coal is that obtained abundantly in Northumberland and Durham, and commonly used in London and everywhere on the east and south coast of England. This kind is also highly bituminous, burns with much flame, and takes fire readily; often assuming a striking and very peculiar appearance, illustrated by a column of coke exhibited by Mr. Cory, and also by other cokes shown by the coal trade of Northumberland and Durham. This caking coal, as it is called, yields on an average of several analyses, about 57 per cent. carbon, about 37.6 volatile matter, and 5 per cent. ash. Its specific gravity is 1.257, but sometimes higher. It leaves a red ash in an open fire, but requires to be deprived of its volatile matter before being exposed to a strong blast, owing to its tendency to cement together in a solid mass and prevent a free draught through the grate or furnace in which it is employed. Not only the coals of the Newcastle coal-field in England, but those of France and Belgium generally, of Bohemia, and Silesia in Europe, and of Ohio in North America, are of the caking bituminous kind.

The coals of Staffordshire, Yorkshire, Derbyshire, Lancashire, North Wales, and

many other districts, contain nearly or quite as much bituminous and volatile matter as that of Newcastle, but do not cake and swell in the fire, and may therefore be employed directly where strong heat is required without previous coking. The coke obtained from this coal is little altered in appearance. The coal burns freely with flame and gives much heat, but is generally considered somewhat inferior for household purposes to that of Newcastle. It yields 50 to 60 per cent. carbon and 35 to 45 volatile matter, and a small quantity, often less than 5 per cent., of ash. The ash is often white. Most of the coals from the inland counties readily show white lines on the edges of the beds, owing to the presence of argillaceous earth which effloresces. In this respect they are less adapted for general use than the Newcastle coal, but many of them are of excellent quality.

Next in order to the coals of the Midland counties generally are those of some parts of North Wales and many districts in South Wales, which contain a larger percentage of carbon, very little volatile matter and bitumen, and often but little ash, which burn however freely, and without smoke, and are all well adapted for steam purposes and the manufacture of iron, or where a strong blast and great heat are required. Such coals exist not only in England, but in France, and Saxony, and Belgium, to some extent. They are often tender or powdery, dirty looking and of comparatively loose texture, but they often stand exposure to the weather without alteration or injury. They are called steam coals, and the inferior kinds are known as culm. They contain carbon 81 to 85, volatile matter 11 to 15, ash 3 or thereabouts. Several varieties well known in commerce are exhibited by different proprietors, and the respective analyses will be found in many cases in the body of the catalogue of the Exhibition.

The last kind of coal is that called "anthracite," and it consists almost exclusively of carbon. This coal is also called non-bituminous, as the steam coal is semi-bituminous. The anthracites contain from 80 to upwards of 95 per cent. carbon, with a little ash and sometimes a certain small percentage of volatile matter. They are heavier than common coal, take fire with difficulty, but give an intense heat when in full combustion with a strong draught. Anthracite occurs abundantly in the western part of South Wales, in the South of Ireland, France, Saxony, Russia, and in North America, and the use of them is greatly on the increase. Amongst other things it is used for hop and malt drying and lime burning with great advantage, but its chief use is in the manufacture of iron. The appearance is often bright with a shining irregular fracture; the coal is often hard, but some varieties are tender and readily fractured. The ash of anthracite coal is generally white. As a general rule, the anthracites are deficient in hydrogen, but contain a certain proportion of oxygen gas.

The relative importance of mineral fuel in various countries, as indicated by the actual coal area and the real production of different districts, may be understood by a reference to the subjoined table. This and other statistical tables are based chiefly upon the authority of Mr. Taylor, but have before been given in their present form by the author of the present essay, Mr. Anstey.

| Countries. | Coal Area in Square Miles. | Proportion of whole Area of the Country. | Annual Production in Tons. |
|--------------------------|----------------------------|--|----------------------------|
| British Islands - - | 12,000 | 1-10 | 32,000,000 |
| France - - - | 2,000 | 1-100 | 4,150,000 |
| Belgium - - - | 520 | 1-22 | 5,000,000 |
| Spain - - - | 4,000 | 1-52 | 550,000 |
| Prussia - - - | 1,200 | 1-90 | 3,500,000 |
| Bohemia - - - | 1,000 | 1-20 | |
| United States of America | 113,000 | 2-9 | 4,000,000 |
| British North America - | 18,000 | | |

It will be thus seen how extremely important the coal fields of the British Islands really are when compared with any others elsewhere. This is the case not merely in the total annual production and the proportionate extent of the deposit, but also from the great number of points at which the coal can be advantageously worked. This will be best seen by reference to the table appended.

TABLE of the principal Coal Fields of the British Islands,

| | Estimated workable Area in Acres. | Number of workable Seams. | Estimated Total Thickness of workable Coal in Feet. | Thickest Bed in Feet. | Total Thickness of Coal-bearing Measures in Feet. |
|--|-----------------------------------|---------------------------|---|-----------------------|---|
| 1. Northumberland and Durham District: — | | | | | |
| Newcastle coal field - - | 500,000 | 18 | 80 | 7 | |
| 2. Cumberland and Westmoreland and West Riding of Yorkshire: — | | | | | |
| Whitehaven and Akerton - | 80,000 | 7 | — | 8 | 2,000 |
| Appleby (three basins) - | 17,000 | | | | |
| Sebergham (Cumberland) - | — | 1 | 3 | 3 | |
| Kirkby Lonsdale - - | 2,500 | 4 | 17 | 9 | |
| 3. Lancashire, Flintshire, and North Staffordshire: — | | | | | |
| Lancashire coal-field - - | 380,000 | 75 | 150 | 10 | 6,000 |
| Flintshire - - - - | 120,000 | 5 | 39 | 9 | 200 |
| Pottery, North Staffordshire | 40,000 | 24 | 28 | 10 | |
| Cheadle - - - - | 10,000 | | | | |
| 4. Yorkshire, Nottinghamshire, Derbyshire, &c.: — | | | | | |
| Great Yorkshire coal-field - | 650,000 | 12 | 32 | 10 | |
| Darley Moor, Derbyshire } Shirley Moor } - - - - | 1,500 | | | | |
| 5. Shropshire and Worcestershire: — | | | | | |
| Coalbrook Dale, Shropshire | 12,000 | 17 | 40 | | |
| Shrewsbury - - - - | 16,000 | 3 | | | |
| Brown, Clee Hill - - - | 1,300 | 3 | | | |
| Titterstone, Clee Hill - - | 5,004 | | | | |
| Lukey Hill, Worcestershire | 650 | | | | |
| Bewdley - - - - | 45,000 | | | | |
| 6. South Staffordshire: — | | | | | |
| Dudley and Wolverhampton | 65,000 | 11 | 67 | 40 | 1,000 |
| 7. Warwickshire and Leicestershire: — | | | | | |
| Nuneaton - - - - | 40,000 | 9 | 30 | 15 | |
| Ashby-de-la-Zouch - - - | 40,000 | 5 | 33 | 21 | |
| 8. Somersetshire and Gloucestershire: — | | | | | |
| Bristol - - - - | 130,000 | 50 | 90 | | |
| Forest of Dean - - - - | 36,000 | 17 | 37 | | |
| Newcut, Gloucestershire - | 1,500 | 4 | 15 | 7 | |
| 9. South Welsh Coal Field - | 600,000 | 30 | 100 | 9 | 12,000 |
| 10. Scottish coal-fields: — | | | | | |
| Clyde Valley } Lanarkshire } South of Scotland, several } small areas } - - - - | 1,000,000 | 84 | 200 | 13 | 6,000 |
| Mid Lothian - - - - | — | 24 | 94 | — | 4,400 |
| East Lothian - - - - | — | 60 | 180 | 13 | 6,000 |
| Kilmarnock } Ayrshire } - - - - | — | 3 | 40 | 30 | |
| Fifehire - - - - | — | — | — | 21 | |
| Dumfries coal region - - | 45,000 | 10 | 55 | 6 | |
| 11. Irish coal fields: — | | | | | |
| Ulster - - - - | 500,000 | 9 | 40 | 6 | |
| Connaught - - - - | 200,000 | | | | |
| Leinster, Kilkenny - - - | 150,000 | 3 | 23 | | |
| Munster (several) - - - | 1,000,000 | | | | |

The beds with which the coal is generally associated in the British islands are various sands and shales (imperfect slaty beds) of different degrees of hardness; but the actual coal seams themselves often repose directly on clay of peculiar fineness, well adapted for fire bricks, and generally called under clay. The under clay is used in many coal districts for various purposes of pottery. Bands of ironstone (impure argillaceous carbonate of iron) are very abundant in certain coal districts, but are almost absent in others. The Scotch coal fields near Glasgow, the South Welsh and some others, are rich in ironstone, which is the chief source of the vast quantities of iron manufactured in this kingdom.

The principal coal-fields of Europe apart from the British Islands are those of France, Belgium, Spain (in the Asturias), Germany (on the Ruhr and Saare), Bohemia, Silesia, and Russia (on the Donetz). Of these the Belgian are the most important, and occupy two districts, that of Liège and that of Hainault, the former containing 100,000 and the latter 200,000 acres. In each the number of coal seams is very considerable, but the beds are thin and so much disturbed as to require special modes of working. The quality of coal is very various, including one peculiar kind, the Flenu coal, unlike any found in Great Britain except at Swansea. It burns rapidly with much flame and smoke, not giving out an intense heat, and having a somewhat disagreeable smell. There are nearly fifty seams of this coal in the Mons district. No iron has been found with the coal of Belgium.

The most important coal-fields of France are those of the basin of Loire, and those of St. Etienne are the best known and largest, comprising about 50,000 acres. In this basin are eighteen beds of bituminous coal, and in the immediate neighbourhood several smaller basins containing anthracite. Other valuable localities are in Alsace, several in Burgundy much worked by very deep pits, and of considerable extent; some in Auvergne with coal of various qualities; some in Languedoc and Provence with good coal; others at Arveyron; others at Limosin; and some in Normandy. Besides these are several others of smaller dimensions and less extent, whose resources have not yet been developed. The total area of coal in France has not been ascertained, but is probably not less than 2,000 square miles. The annual production is now at least 4,000,000 tons.

There are four coal districts in Germany of the carboniferous period, besides several districts where more modern lignites occur. The principal localities for true coal are near the banks of the Rhine in Westphalia; on the Saare, a tributary of the Moselle; in Bohemia and in Silesia, the total annual production exceeds 2,750,000 tons.

Of these various localities, Silesia contains very valuable and extensive deposits of coal, which are as yet but little worked. The quality is chiefly bituminous, the beds few in number but very thick, amounting in some cases to 20 feet. Some anthracite is found. Bohemia is even more richly provided than Silesia, the coal measures covering a considerable area and occupying several basins. More than 40 seams of coal are worked, and several of these are from 4 to 6 feet thick.

The basin of the Saare, a tributary of the Moselle, near the frontier of France, affords a very important and extensive coal field, which has been a good deal worked and is capable of great improvement. No less than 103 beds are described, the thickness varying from 18 inches to 15 feet. It is estimated that at the present rate of extraction the basin contains a supply for 60,000 years. On the banks of the Ruhr, a small tributary to the Rhine, entering that river near Dusseldorf, there is another small coal field estimated to yield annually 1,000,000 tons. The whole annual supply from Prussia and the German States of the Zollverein or Customs' Union, is considered to exceed 2,750,000 tons.

Hungary and other countries in the east of Europe contain true coal measures of the carboniferous period; but the resources of these districts are not at present developed. On the banks of the Donetz in Russia, coal is worked to some extent and is of excellent quality, but it belongs to the other part of the carboniferous period.

Spain contains a large quantity of coal, both bituminous and anthracite. The richest beds are in Asturias, and the measures are so broken and altered as to be worked by almost vertical shafts through the beds themselves. In one place upwards of 11 distinct seams have been worked, the thickest of which is nearly 14 feet. The exact area is not known, but it has been estimated by a French engineer that about 12,000,000 of tons might be readily extracted from one property without touching the portion existing at great depths. In several parts of the province the coal is now worked, and the measures seem to resemble those of the coal districts generally. The whole coal area is said to be the largest in Europe, presenting upwards of 100 workable seams varying from 3 to 12 feet in thickness.

There are in North America four principal coal areas; compared with which the richest deposits of other countries are comparatively insignificant. These are the great central coal-fields of the Alleghanies; the coal-fields of Illinois, and the basin of the Ohio; that of the basin of the Missouri; and those of Nova Scotia, New Brunswick, and Cape

Breton. Besides, there are many smaller coal areas which, in other countries, might well take rank as of vast national importance, and which even in North America will one day contribute greatly to the riches of various States.

The Alleghany or Appalachian coal field measures 750 miles in length, with a mean breadth of 85 miles, and traverses eight of the principal States in the American Union. Its whole area is estimated at not less than 65,000 square miles, or upwards of 40,000 square acres.

The coal is bituminous and used for gas. In Kentucky both bituminous and cannel coal are worked in seams about 3 or 4 feet deep, the cannel being sometimes associated with the bituminous coal as a portion of the same seam; and there are in addition valuable bands of iron ore. In Western Virginia there are several coal fields of variable thickness, one, $9\frac{1}{2}$ feet; two others of 5, and others of 3 or 4 feet. On the whole there seems to be at least 40 feet of coal distributed in 13 seams. In the Ohio district the whole coal field affords on an average at least 6 feet of coal. The Maryland district is less extensive, but is remarkable as containing the best and most useful coal, which is worked now to some extent at Frostbury. There appears to be about 30 feet of good coal in four seams, besides many others of less importance. The quality is intermediate between bituminous and anthracite, and is considered well adapted for iron making. Lastly, in Pennsylvania there are generally from two to five workable beds, yielding on an average 10 feet of workable coal, and amongst them is one bed traceable for no less than 450 miles, consisting of bituminous coal, its thickness being from 12 to 14 feet on the south-eastern border, but gradually diminishing to 5 or 6 feet. Besides the bituminous coal there are in Pennsylvania the largest anthracite deposits in the States, occupying as much as 250,000 acres and divided in three principal districts.

The Illinois coal field, in the plane of the Mississippi, is only second in importance to the vast area already described. There are four principal divisions traceable, of which the first, or Indian district, contains several seams of bituminous coal distributed over an area of nearly 8,000 square miles. It is of excellent quality for many purposes; one kind burning with much light and very freely, approaching cannel coal in some of its properties; other kinds consist of caking or splint coal. In addition to the Indian coal-field there appears to be as much as 48,000 square miles of coal area in other divisions of the Illinois district, although these are less known and not at present much worked. 30,000 are in the state of Illinois, which supplies coal of excellent quality, and with great facility. The coal is generally bituminous.

The third great coal area of the United States is that of the Missouri, which is little known at present, although certainly of great importance.

British America contains coal in the provinces of New Brunswick and Nova Scotia. The former presents three coal-fields, occupying in all no less than 5,000 square miles; but the latter is far larger and exhibits several very distinct localities where the coal abounds. The New Brunswick coal measures include not only shales and sandstones, as is usual with such deposits, but bands of lignite impregnated with various copper ore, and coated by green carbonate of copper. The coal is generally in thin seams lying horizontally. It is chiefly or entirely bituminous.

In Nova Scotia there are three coal regions, of which the Northern presents a total thickness of no less than 14,570 feet of measures, having 70 seams, whose aggregate magnitude is only 44 feet, the thickest beds being less than 4 feet. The Pictou or central district, has a thickness of 7,590 feet of strata, but the coal is far more abundant, one seam measuring nearly 30 feet; and part of the coal being of excellent quality and adapted for steam purposes. The southern area is of less importance. Besides the Nova Scotia coal-fields there are three others at Cape Breton, yielding different kinds of coal, of which one, the Sydney coal, is admirably adapted for domestic purposes. There are here 14 seams above 3 feet thick, one being 11, and one 9 feet.

Coal, existing generally in beds of moderate thickness inclined at a small angle to the horizon and often at a very considerable depth beneath the surface, is extracted most commonly by the aid of pits or shafts sunk to the bed and galleries (levels of drifts), cut horizontally or in the plane of the bed to a certain distance. By a number of such galleries cut at right angles to each other, the whole bed, within certain limits, is completely laid open, the overlying beds being supported by the masses of coal (pillars or columns) left untouched between the galleries; in this way about one third of the coal can be extracted, and afterwards, on the supporting columns being removed, the roof falls in and the work is regarded as finished. This method is called technically the "pillar and stall method," and is adopted in the Newcastle coal-field. In Yorkshire and elsewhere, instead of such columns being left, the coal is removed entirely and at once without columns; the roof falling behind the work as it advances. This is the long wall method. Other modes are occasionally followed when the condition of the coal requires it.

Owing to the gaseous substances contained in coal and given off, not only on exposure to heat, but also, to a certain extent, by pressure, many kinds of coal cannot safely be left

during the process of extraction without some defence from the open lights required by the miner in the mechanical operations of removing the coal from its bed and conveying it to the pit bottom. An explosive gaseous compound is readily produced by the mixture of the gases given off by the coal, with common air, made to circulate through the workings, and if neglected, this compound accumulates, and travels on till it meets with flame, and then explodes, causing frightful destruction, not only to the property of the mine owner, but also to the life of the miner. Many contrivances have been suggested from time to time, on one hand to improve the ventilation of the mines, and, on the other, providing means of illumination which would render accidents from explosion less probable, by removing the immediate cause. Examples of both will be found amongst the models and instruments exhibited in this class of the Exhibition. It is not likely that any contrivances can render absolutely safe an employment which of necessity involves so many and such serious risks as are connected with coal mining; but much may no doubt be done to diminish the danger both from imperfect ventilation and open light.

In concluding this notice of mineral fuel, it may be worth while to draw attention to the vast and overwhelming importance of the subject by a reference both to the absolute and relative value of the material, especially in the British Islands. It may be stated as probably within the true limit, if we take the annual produce of the British coal mines at 35,000,000 tons, the value of which is not less than 18,000,000*l.* sterling, estimated at the place of consumption, and therefore including a certain amount of transport cost necessary to render available the raw material. At the pit mouth the value of the coal is probably about half this, or 9,000,000*l.* sterling, and the capital employed in the coal trade is estimated at 10,000,000*l.* The average annual value of all the gold and silver produced throughout the world has been estimated to have amounted in 1847, to nearly thirteen millions and three quarters sterling. We have, therefore, the following summary, which will not be without interest.

| | | | | |
|---|---|---|---|------------|
| Value of the coal annually raised in Great Britain, estimated at the pit mouth | - | - | - | 9,000,000 |
| Mean annual value at the place of consumption | - | - | - | 18,000,000 |
| Capital engaged in the coal trade | - | - | - | 10,000,000 |
| Mean annual value of the precious metals obtained from North and South America and Russia | - | - | - | 5,000,000 |
| Total value of precious metals raised throughout the whole world | - | - | - | 13,000,000 |
| Mean annual value at the furnace of iron produced from British coal | - | - | - | 8,000,000 |

Boghead Coal.—At Boghead, near Bathgate, in Scotland is a very valuable gas coal. The mineral substance so called is a true coal, and belongs to the great coal formation of this island. It differs in no essential respect from the Cannel coal found in the south-west of Scotland, in North Wales, and in many parts of England. It contains the same remains of plants which characterise the coal formation all over the world, that is to say, impressions of *sigillaria*, *stigmara*, &c. In a chemical point of view, the resemblance becomes much more striking, and is altogether so decisive that I do not hesitate to declare, in the most positive manner, my opinion that the Boghead coal is as much a coal as any other coal in the kingdom.

The conchoidal fracture, the specific gravity, and the general habitude when burnt, are precisely like those of the whole of the coal found in and around the Boghead district, and many striking points of resemblance may be noticed in these and other respects between the Boghead and other coals from the south of Scotland, such as the Kirkness, the Arniston, the Wemyss, the Capeldrae, &c., as well as with many from England, Wales, and even India, as will be shown hereafter. Thus the nature of the gases they evolve by heat is the same,—they are all proof against heated naphtha, oil of turpentine, æther, &c.—they are equally so against dilute alkaline and acid solutions—in chemical composition they are alike—the ash is the same, and indicates a common origin, whereas, in these respects, all these coals differ totally from every form of bitumen, lignite, retinite, and bituminous shale which has yet come under my notice. It would be a work of supererogation to enter more fully into a detail of these particulars, nor is this at all necessary towards the completion of my proof. I have asserted that the Boghead coal is a true coal, and belongs to the Cannel variety of that mineral. In support of this assertion I append the following table of coals analysed for this purpose, and proving beyond all contradiction that it is not even at the extreme limit of the class to which it belongs, but occupies a central and very unequivocal position in the Cannel coal series.

| Name of Substance. | Specific Gravity. | Per Centage of Combustible Matters. | Per Cent. of Ash. | Nature of Ash. | Remarks. |
|------------------------|-------------------|-------------------------------------|-------------------|---|---|
| New Brunswick Asphalt. | 1.098 | 99.4 | .6 | Silica - - | Largely soluble in naphtha, oil of turp., æther, and sulphuret of carbon. |
| Indian coal, No. 1. - | 1.268 | 87.5 | 12.5 | Trisilicate of alumina. | Insoluble in the above and in dilute acids. |
| No. 2. - | 1.290 | 88. | 12. | Ditto - - - | Ditto ditto. |
| Lesmahago - - | 1.220 | 90.9 | 9.1 | Ditto - - - | Ditto ditto. |
| Capeldrae - - | 1.237 | 89.5 | 10.5 | Ditto - - - | Ditto ditto. |
| Lockgelly - - | 1.320 | 86.9 | 13.1 | Ditto - - - | Ditto ditto. |
| Kirkness - - | 1.215 | 86.5 | 13.5 | Ditto - - - | Ditto ditto. |
| Old Wemyss - - | 1.325 | 84.9 | 15.1 | Ditto - - - | Ditto ditto. |
| Boghead - - | 1.223 | 77.2 | 22.8 | Ditto - - - | Ditto ditto. |
| Brymbo Cannel, No. 1 | 1.574 | 66.8 | 33.2 | Ditto - - - | Ditto ditto. |
| No. 2. | 1.620 | 68.8 | 31.2 | Ditto - - - | Ditto ditto. |
| Sheffield Cannel - | 1.626 | 66. | 34. | Ditto - - - | Ditto ditto. |
| Portland Shale - | 1.766* | 48.9 | 51.1 | Carb., phosphate, and silicate of lime with sand. | Slightly soluble. Acted on with slight effervescence. |
| Seysell Asphalt - | 1.780* | 57.8 | 42.2 | Carbonate of lime only. | Largely soluble. Rapidly acted on with effervescence. |

PITCOAL. (*Exhibition.*)—*Alvio Musbach, Vienna, Proprietor.*—The coal mines of this exhibitor are the most extensive in the empire; his thirty mines contain a store of at least 900,000,000 cwt. of coal, whereof 864,000,000 have been discovered by himself. They give direct employment to 1,961 men, produce annually 2,750,000 cwt. of coal, and are already in a condition to furnish four times that quantity, although the greater part of them are only now being opened and prepared for working.

Coal is found in Austria in constantly increasing quantities, particularly in Bohemia, Moravia, Silesia, Lower Austria, and Hungary. Bohemia takes the first place as to the quantity, and partly also as to the quality of its coal, nearly half the total quantity of the coal and brown coal produced in Austria being Bohemian. Considered generally, however, the production of coal is only trifling at present.

The production of coal in 30 years has increased tenfold; and at a rapid ratio. The prices of wood and charcoal are constantly increasing with an annually increasing demand for fuel to be consumed in factories, &c. It is therefore very probable that the collieries of Austria will at no distant period be worked to a far greater extent than at present. Scarcely 100,000 cwt. of coals are extracted in a year from coal-fields that are known to contain as much as 1500 millions of cwt. The exports of Austria exceed the imports of foreign coal by about 300,000 cwt. A large proportion of the fuel obtained in Austria is lignite.

This substance, which is intermediate in its character between wood and coal, and is of a brown colour, possesses considerable value as a calorific agent, although it is in this respect inferior to the coal of Great Britain. Its importance to the countries and districts where it is found can scarcely be exaggerated, and its abundance justifies the belief that the enormous thick detached beds in which it occurs, will ere long be fully worked. The lignite not infrequently presents those evidences of its origin from the decomposition of coniferous trees, from which the geologist draws his most accurate inferences.

Immediately abutting, as it were, on the confines of raw material, the manufacture of coal-gas claims attention from its amphibious position and multifarious uses. As bituminous coal when subjected to the action of red-heat, invariably gives a gaseous matter wherever placed, it becomes necessary to distinguish between the production of coal-gas and its manufacture. Our ancestors were producers of coal-gas; but the manufacture of this important agent belongs to the present century; and therefore we are able, without any difficulty, to speak of the production and manufacture separately. The production of gas from coal depends altogether upon the application of a high temperature; for, at a heat verging on 400° Fahr., the volatile constituents of coal pass off in the shape of fluid hydrocarbons, or naphtha, with little or no admixture of any permanent gas. If, however, the temperature employed be that known as a full cherry-red heat, or something higher, then the volatile constituents are for the most part resolved into permanently elastic fluids or gases, with a trifling production of tar and naphtha. Too high a heat is, however, apt to induce some grave inconveniences, as will appear further on; and hence the gas maker, in its first process, sails between a kind of Scylla and Charybdis, having to dread an excessive production of tar on the one hand, and the evils just alluded to on the other. Presuming, however, that the proper temperature has been secured, the successful production of good coal-gas is not yet ensured, unless the coals, before their introduction into the retort, are free, or nearly so, from water. Coal is a bad conductor

* Very variable.

of heat; and therefore when a quantity of this substance in a wet condition is thrown into a red-hot retort, as precisely by gas manufacturers, the outer portion of this mass becomes carbonized and converted into red-hot coke long before the water in the centre of the coal has been expelled; consequently, as the heat penetrates through the coal, this water is vaporized, and driven in the form of steam over the red-hot coals on the surface, with the production of three gases, viz., hydrogen, carbonic oxide, and carbonic acid, all of which are injurious to the gas maker; the two first by diluting his gas and lowering its illuminating power; the last, by neutralizing the lime contained in the purifier, and thus needlessly causing an increased consumption of that article. But the presence of water in coal is also detrimental in another way; for its conversion into steam implies the absorption of an immense amount of heat, since the latent heat of steam is upwards of 960° ; consequently, as this absorption takes place immediately previous to the decomposition of the bituminous constituents of the coal, a disposition results to generate at that time a temperature capable only of producing tar or naphtha, but scarcely equal to the formation of coal-gas; and thus water not only tends to reduce the quality, but also to lessen the quantity, of gas procurable from any given coal; therefore its absence in coals intended for gas purposes should always be ascertained prior to their employment.

We have previously remarked, that too high a temperature ought to be avoided in the production of coal-gas, and this for two very important reasons. In the first place heavy carburetted hydrogen or olefiant gas is decomposed at a white heat, or even under this, with the formation of light carburetted hydrogen, and the production of charcoal or carbon, thus greatly diminishing the value of the gas as an illuminating agent. The second reason is still more conclusive. All coals contain iron pyrites, which, at a low red-heat, is decomposed into protosulphuret of iron and free sulphur; the latter uniting to a portion of the hydrogen of the coal passes off, and is found in the gas in the shape of sulphuretted hydrogen, leaving the protosulphuret of iron in the retort. But it will be remembered that in speaking of coke we mentioned that this protosulphuret of iron was resolved by a high and long sustained heat into metallic iron, which remained in the coke, and into the bisulphuret of carbon, which escaped. Now, the application of a high heat in gas making has exactly the same effect as in coke-making, and produces in both cases bisulphuret of carbon, which, mixing with the coal-gas, can never afterwards be removed. It consequently remains in the gas, and when this is burnt in the ordinary way, gives rise to the production of sulphuric acid or oil of vitriol; and this, although generated by most of the common gas of our streets in an infinitesimal quantity, is nevertheless found sufficient, in a few years, to attack and destroy the binding and paper of the books in our public libraries, and corrode articles of iron, steel, brass, or copper. This important fact has not received a proper share of consideration from our best gas engineers until within the last few months; and hence many of the old libraries of London can now furnish books completely discoloured and rotted through a great portion of each page, though in a few years all further traces of this mischievous effect of gas will have vanished.

Having thus far commented on the production of coal-gas, we next pass to the examination of the processes employed in rendering it pure and fit for the uses to which it is applied in common life. The first process is that of condensation, by which nearly the whole of the vapours, properly so termed, are condensed and separated from the permanently elastic gases. By this means, tar, water, naphtha, carbonate, muriate, and hydrosulphurate of ammonia, are removed from the gas, the only impurities of which now are carbonate of ammonia, carbonic acid, and sulphuretted hydrogen. Water alone will remove all three of these impurities; but its action is weak, and chiefly exercised upon the first. Hence, although usefully employed for attracting carbonate of ammonia (as exemplified in Lowe's scrubber), it is not used by gas engineers of the present day, with a view to total purification, this being sought for in the superior affinity of lime, after the ammonia has been arrested by other means. Coal-gas, after condensation, usually contains about 2 per cent. of carbonic acid, and 1 per cent. of sulphuretted hydrogen; but these vary, of course, with the nature of the coal, and also, as we have stated above, with the dryness of the coal, which has much to do with the production of carbonic acid. These proportions may, however, be regarded as a fair average of Newcastle coal-gas, and would justify the consumption of about 40 lbs. of lime for every 10,000 cubic feet of gas; a quantity which, although far below the proportion expended in common practice, is really very near the consumption of lime carried out at the Westminster station of the Chartered Gas Company, by Mr. F. J. Evans, during a long course of carefully conducted experiments, and ought, therefore, to be kept in view as an ultimatum by gas engineers. Where much more lime than is found indispensable to good purification, there is reason to suspect either that the coal is damp, or that it contains more than an average quantity of sulphur. The amount of sulphur in good Newcastle coal is as nearly as possible 1 per cent. by weight, and in some of the cannel coals

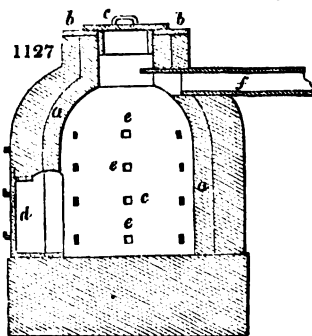
it is even less ; thus Boghead Cannel, for example, has barely one-half per cent., or .54 of sulphur, on an average. How necessary, then, is it that every gas engineer should be able to determine the quantity of sulphur existing in coal ! but even this, without other knowledge, is worthless and deceptive. Sulphur seems to be present in coal in two states ; the one and most frequent is that in which it is united to iron, as bisulphuret of iron or pyrites ; the other is in a doubtful state of combination, but probably it exists conjoined to the bituminous elements of the coal in the state of sulphur. To the gas maker this difference is very important, as in the former case, one-half only of the total sulphur would pass away with the gas and contaminate it, whereas in the second, the whole would be carried to the purifying vessels ; consequently, in determining the amount of sulphur in coal, a gas engineer must ascertain first how much sulphur the pure coal contains, and next how much sulphur remains in an equivalent of the coke of such coal ; after which the latter must be deducted from the former to get at the sulphur contamination of the coal, when its value for gas purposes is sought to be determined.

The following detailed explanation will furnish the gas engineer with a means by which coal may be analyzed, with a view to the object in question. Having carefully reduced a fair sample of the coal to a very fine powder, mix 100 grains of this powder with 50 grains of pure and dry carbonate of soda ; after which place the mixture in a clear iron ladle, and roast the whole over a brisk fire, at a good red heat for several minutes, so as to burn off the whole of the coal, or nearly so ; then remove the ladle from the fire, and when it is cold, add 50 grains of pure and powdered nitre, mixing this well with the residue of the coal and carbonate of soda ; after which, place the ladle again on the fire and keep it red hot for a few minutes, when it must be again removed, suffered to cool, and its soluble contents washed out with water and thrown on a filter. To the filtered liquor an excess of pure nitric acid must be added, and then a solution of nitrate of baryta dropped in until all precipitation ceases ; when the sulphate of baryta, thus formed, may be allowed to settle, or be thrown on a counterpoise filter, washed, dried, and weighed. Its equivalent, or 117 grains, indicates 16 grains of sulphur.

Having thus determined the quantity of sulphur in the coal, 100 grains more of the powdered coal are to be taken and placed in an earthen crucible, provided with a closely fitting cover : when the cover is put on, the crucible is subjected to a red heat until inflammable gas is no longer evolved ; the crucible must then be removed and covered up in dry sand to cool. As soon as the crucible is cold, remove the coke it contains, and after reducing it to a fine powder, mix with it 50 grains of pure and dry carbonate of soda ; place the whole in an iron ladle, and proceed exactly as indicated above with respect to coal. The amount of sulphur found in the coke must then be deducted from that previously ascertained to exist in the coal, the difference being the true sulphur contamination of the coal under examination.

PITCOAL, COKING OF. See also CHARCOAL.

Fig. 1127. represents a *shachtlofen*, or pit-kiln, for coking coals in Germany. *a* is the

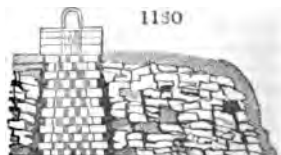
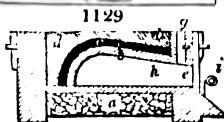
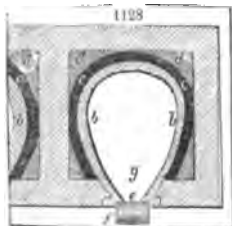


lining (*chemise*), made of fire-bricks ; the enclosing walls are built of the same material ; *b, b*, is a cast-iron ring covered with a cast-iron plate *c*. The floor of the kiln is massive. The coals are introduced, and the coke taken out, through a hole in the side *d* ; during the process it is bricked up, and closed with an iron door. In the surrounding walls are 4 horizontal rows of flues *e, e, e, e*, which are usually iron pipes ; the lowest row is upon a level with the floor of the kiln ; and the others are each respectively one foot and a half higher than the preceding. Near the top of the shaft there is an iron pipe *f*, of from 8 to 10 inches in diameter, which allows the incoercible vapours generated in the coking to escape into the condenser, which consists either of wood or brick chambers. For kindling the coal, a layer of wood is first placed on the bottom of the kiln.

The coking of small coal is performed upon vaulted hearths, somewhat like bakers, ovens, but with still flatter roofs. Of such kilns, several are placed alongside one another, each being an ellipse deviating little from a circle, so that the mouth may project but a small space. The dimensions are such, that from 10 to 12 cubic feet of coal-culm may be spread in a layer 6 inches deep upon the sole of the furnace. The top of the flat arch of fire brick should be covered with a stratum of loam and sand.

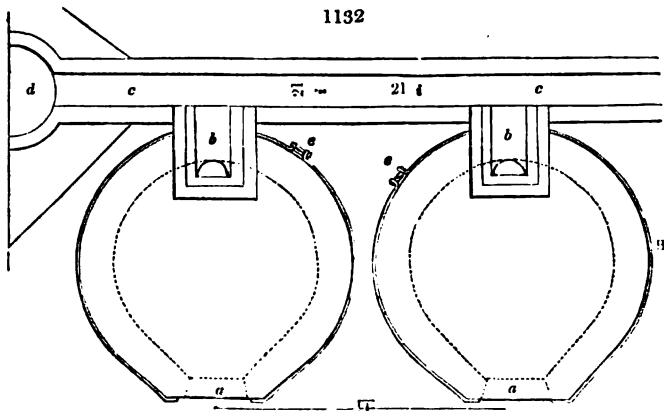
Figs. 1128, & 1129. represent such a kiln as is mounted at Zabrze, in Upper Silesia, for coking small coal. Fig. 1128. is the ground plan ; fig. 1129. the vertical section in

the line of the long axis of *fig. 1128*. *a*, is the sand-bed of the hearth, under the brick sole; *b*, is the roof of large fire-bricks; *c*, the covering of loam; *d*, the top surface of sand; *e*, the orifice in the front wall, for admission of the culm, and removal of the coke, over the sloping stone *f*. The flame and vapours pass off above this orifice, through the chimney marked *g*, or through the aperture *h*, into a lateral chimney. *i*, is a bar of iron laid across the front of the door, as a fulcrum to work the iron rake upon. A layer of coals is first kindled upon the hearth, and when this is in brisk ignition, it is covered with the culm in successive sprinklings. When the coal is sufficiently coked, it is raked out, and quenched with water.

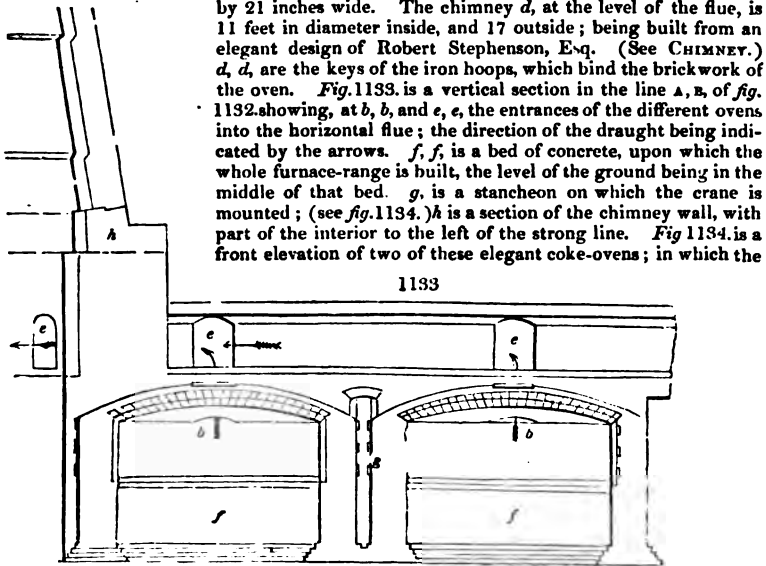


length, and from 10 to 12 in breadth. The section in the middle of the figure shows how the lumps are piled up; the wooden stakes are lifted out when the heap is finished, in order to introduce kindlings at various points; and the rest of the meiler is then covered with slack and clay, to protect it from the rains. A jet of smoke and flame is seen issuing from its left end.

An excellent range of furnaces for making a superior article of coke, for the service of the locomotive engines of the London and Birmingham Railway Company, has been recently erected at the Camden Town station; consisting of 18 ovens in two lines, the whole discharging their products of combustion into a horizontal flue, which terminates



in a chimney-stalk, 115 feet high. *Fig. 1132*, is a ground plan of the elliptical ovens, each being 12 feet by 11 internally, and having 9 feet thickness of walls. *a, a*, is the mouth, $3\frac{1}{2}$ feet wide outside, and about $2\frac{3}{4}$ feet within. *b, b*, are the entrances into the flue; they may be shut more or less completely by horizontal slabs of fire-brick, resting on iron frames, pushed in from behind, to modify the draught of air. The grooves of these damper-slabs admit a small stream of air to complete the combustion of the volatilized particles of soot. By this means the smoke is well consumed. The flue *c, c*, is $2\frac{1}{2}$ feet high,

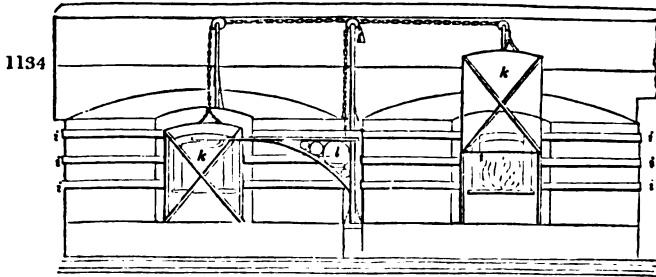


by 21 inches wide. The chimney *d*, at the level of the flue, is 11 feet in diameter inside, and 17 outside; being built from an elegant design of Robert Stephenson, Esq. (See CHIMNEY.) *d*, *d*, are the keys of the iron hoops, which bind the brickwork of the oven. Fig. 1133. is a vertical section in the line A, B, of fig. 1132. showing, at *b*, *b*, and *e*, *e*, the entrances of the different ovens into the horizontal flue; the direction of the draught being indicated by the arrows. *f*, *f*, is a bed of concrete, upon which the whole furnace-range is built, the level of the ground being in the middle of that bed. *g*, is a stanchion on which the crane is mounted; (see fig. 1134.) *h* is a section of the chimney wall, with part of the interior of the strong line. Fig 1134. is a front elevation of two of these elegant coke-ovens; in which the

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bracing hoops *i*, *i*, are shown; *k*, *k*, are the cast-iron doors, strengthened outside with diagonal ridges; each door being 5½ feet high, by 4 feet wide, and lined internally with fire-bricks. They are raised and lowered by means of chains and counterweights, moved by the crane *L*.

Each alternate oven is charged, between 8 and 10 o'clock every morning, with 3½ tons of good coals. A wisp of straw is thrown in on the top of the heap, which takes fire by the radiation from the dome (which is in a state of dull ignition from the preceding operation), and inflames the smoke then rising from the surface, by the reaction of the



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hot sides and bottom upon the body of the fuel. In this way the smoke is consumed at the very commencement of the process, when it would otherwise be most abundant. A neighbour of the above coking ovens, having lately indicted them as a nuisance, procured, *secundum artem*, a parcel of affidavits from sundry chemical and medical men. Two of the former, who had not entered the premises, but had espied the outside of the furnaces' range at some distance, declared that "the coking process, as performed at the ovens, is a species of distillation of coal!" How rashly do unpractical theorists affirm what is utterly unfounded, and mislead an unscientific judge! That the said coking process is in no respect a species of distillation, but a complete combustion of the volatile principles of the coal, will be manifest from the following description of its actual progress. The mass of coals is first kindled at the surface, as above stated, where it is supplied with abundance of atmospheric oxygen; because the doors of the ovens in front, and the throat-vents behind, are then left open. The consequence is, that no more smoke is discharged from the top of the chimney, at this the most sooty period of the process, than is produced by an ordinary kitchen fire. In these circumstances, the coal gas, or other gas, supposed to be generated in the slightly heated mass beneath

cannot escape destruction in passing up through the bright open flame of the oven. As the coking of the coal advances most slowly and regularly from the top of the heap to the bottom, only one layer is affected at a time, and in succession downwards, while the surface is always covered with a stratum of red hot cinders, ready to consume every particle of carburetted or sulphuretted hydrogen gases which may escape from below. The greatest mass when calcined in this downward order, cannot emit into the atmosphere any more of the above-mentioned gases than the smallest heap; and therefore the argument raised on account of the magnitude of the operations is altogether fallacious.

The coke being perfectly freed from all fuliginous and volatile matters by a calcination of upwards of 40 hours, is cooled down to moderate ignition by sliding in the dampers, and sliding up the doors, which had been partially closed during the latter part of the process. It is now observed to form prismatic concretions, somewhat like a columnar mass of basalt. These are loosened by iron bars, lifted out upon shovels furnished with long iron shanks, which are poised upon swing chains with hooked ends, and the lumps are thrown upon the pavement, to be extinguished by sprinkling water upon them from the rose of a watering-can; or, they might be transferred into a large chest of sheet-iron set on wheels and then covered up. Good coals, thus treated, yield 80 per cent. of an excellent compact glistening coke; weighing about 14 cwt. per chaldron.

The loss of weight in coking in the ordinary ovens is usually reckoned at 25 per cent.; and coal, which thus loses one-fourth in weight, gains one-fourth in bulk.

Labourers who have been long employed at rightly-constructed coke ovens seem to enjoy remarkably good health.

PITTACALL, is one of the 6 curious principles detected in wood-tar by Reichenbach. It is a dark-blue solid substance, somewhat like indigo, assumes a metallic fiery lustre on friction, and varies in tint from copper to golden. It is void of taste and smell, not volatile; carbonizes at a high heat without emitting an ammoniacal smell; is soluble or rather very diffusible in water; gives a green solution with a cast of crimson, in sulphuric acid, with a cast of red blue, in muriatic acid, and with a cast of aurora red, in acetic acid. It is insoluble in alkalia. It dyes a fast blue upon linen and cotton goods, with tin and aluminous mordants.

PLASTER; see **MORTAR**.

PLASTER OF PARIS; see **GYP-SUM**.

PLATE-CLEANING. Boil 30 grms. of finely pulverized and calcined hartshorn in a quart of water, and while on the fire put as many silver articles in the vessels used for boiling as it will hold, and leave them there for a short time; then withdraw them, and dry them over the fire; continue this until all the articles have been treated in the same manner; then introduce into the hartshorn water clean woollen rags, and allow them to remain until saturated, after which dry them, and use them for polishing the silver. This is also the best substance for cleaning locks and brass handles of room doors. When the silver articles are perfectly dry, they must be carefully rubbed with a soft leather. This mode of cleaning is excellent, and much preferable to the employment of any powder containing mercury, as mercury has the effect of rendering the silver so brittle as to break on falling.—*C. Gaz.* 1849, p. 362.

PLATED MANUFACTURE. (*Fabrique de plaqué*, Fr.; *Silber plattirung*, Germ.) The silver in this case is not applied to ingots of pure copper, but to an alloy consisting of copper and brass, which possesses the requisite stiffness for the various articles.

The furnace used for melting that alloy, in blacklead crucibles, is a common air-furnace, like that for making brass.

The ingot-moulds are made of cast-iron, in two pieces, fastened together; the cavity being of a rectangular shape, 3 inches broad, $1\frac{1}{2}$ thick, and 18 or 20 long. There is an elevated mouth-piece or gate, to give pressure to the liquid metal, and secure solidity to the ingot. The mould is heated, till the grease with which its cavity is besmeared merely begins to smoke, but does not burn. The proper heat of the melted metal for casting, is when it assumes a bluish colour, and is quite liquid. Whenever the metal has solidified in the mould, the wedges that tighten its rings are driven out, lest the shrinkage of the ingot should cause the mould to crack. See **BRASS**.

The ingot is now dressed carefully with the file on one or two faces, according as it is to be single or double plated. The thickness of the silver plate is such as to constitute one-fortieth of the thickness of the ingot; or when this is an inch and a quarter thick, the silver plate applied is one thirty-second of an inch; being by weight a pound troy of the former, to from 8 to 10 pennyweights of the latter. The silver, which is slightly less in size than the copper, is tied to it truly with iron wire, and a little of a saturated solution of borax is then insinuated at the edges. This salt melts at a low heat, and excludes the atmosphere, which might oxidize the copper, and obstruct the union of the metals. The ingot thus prepared is brought to the plating furnace.

The furnace has an iron door with a small hole to look through; it is fed with coke

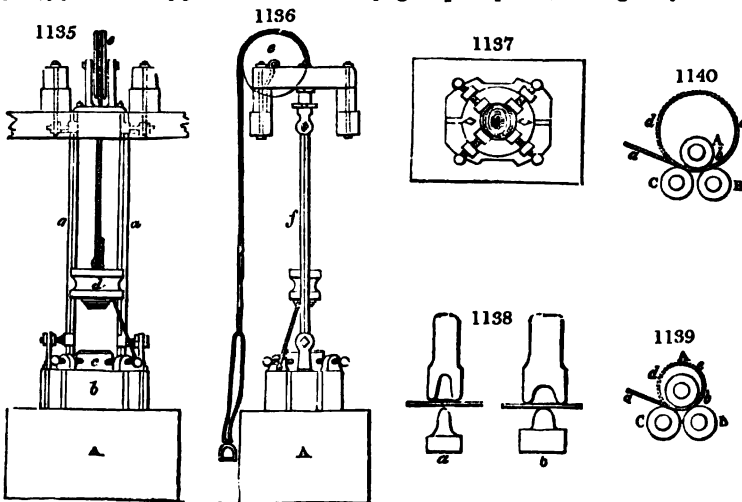
laid upon a grate at a level with the bottom of the door. The ingot is placed immediately upon the cokes, the door is shut, and the plater watches at the peep-hole the instant when the proper soldering temperature is attained. During the union of the silver and copper, the surface of the former is seen to be drawn into intimate contact with the latter, and this species of *rivetting* is the signal for removing the compound bar instantly from the furnace. Were it to remain a very little longer, the silver would become alloyed with the copper, and the plating be thus completely spoiled. The adhesion is, in fact, accomplished here by the formation of a film of true silver-solder at the surfaces of contact.

The ingot is next cleaned, and rolled to the proper thinness between cylinders as described under *MIXT*; being in its progress of lamination frequently annealed on a small reverberatory hearth. After the last annealing, the sheets are immersed in hot dilute sulphuric acid, and scoured with fine Calais sand; they are then ready to be fashioned into various articles.

In plating copper wire, the silver is first formed into a tubular shape, with one edge projecting slightly over the other; through which a red-hot copper cylinder being somewhat loosely run, the silver edges are closely pressed together with a steel burnisher, whereby they get firmly united. The tube thus completed is cleaned inside, and put on the proper copper rod, which it exactly fits. The copper is left a little longer than its coating tube, and is grooved at the extremities of the latter, so that the silver edges, being worked into the copper groove, may exclude the air from the surface of the rod. The compound cylinder is now heated red-hot, and rubbed briskly over with the steel burnisher in a longitudinal direction, whereby the two metals get firmly united, and form a solid rod, ready to be drawn into wire of any requisite fineness and form; as flat, half-round, fluted, or with mouldings, according to the figure of the hole in the draw-plate. Such wire is much used for making bread-baskets, toast-racks, snuffers, and articles combining elegance with lightness and economy. The wire must be annealed from time to time during the drawing, and finally cleaned, like the plates, with dilute acid.

Formerly the different shaped vessels of plated metal were all fashioned by the hammer; but every one of simple form is now made in dies struck with a drop-hammer or stamp. Some manufacturers employ 8 or 10 drop machines.

Fig. 1135. & *1136.* are two views of the stamp: *a* is a large stone, the more massy the better; *b*, the anvil on which the die *e* is secured by four screws, as shown in the ground plan, *fig. 1137.* In *fig. 1135*, *a a* are two upright square prisms, set diagonally with the

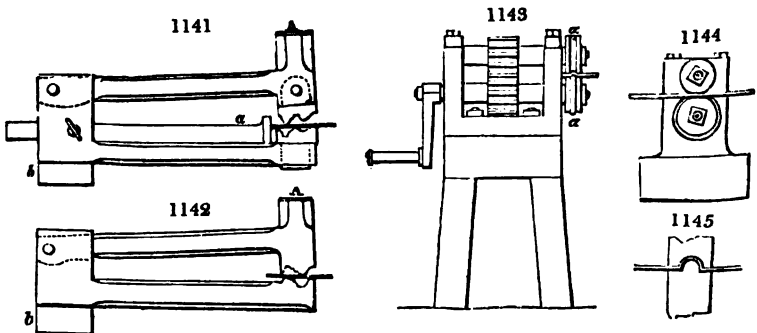


angles opposed to each other; between which the hammer or drop *d* slides truly, by means of nicely fitted angular grooves or recesses in its sides. The hammer is raised by pulling the rope *f*, which passes over the pulley *e*, and is let fall from different heights, according to the impulse required. Vessels which are less in diameter at the top and bottom than in the middle, must either be raised by the stamp in two pieces, or raised by a hand hammer. The die is usually made of *cast steel*. When it is placed upon the

anvil, and the plated metal is cut into pieces of proper size, the top of the die is then surrounded with a lute made of oil and clay, for an inch or two above its surface; and the cavity is filled with melted lead. The under face of the stamp-hammer has a plate of iron called the *licker-up* fitted into it, about the area of the die. Whenever the lead has become solid, the hammer is raised to a certain height, and dropped down upon it; and as the under face of the licker-up is made rough like a rasp, it firmly adheres to the lead, so as to lift it afterwards with the hammer. The plated metal is now placed over the die, and the hammer mounted with its lead is let fall repeatedly upon it, till the impression on the metal is complete. If the vessel to be struck be of any considerable depth, two or three dies may be used, of progressive sizes in succession. But it occasionally happens that when the vessel has a long conical neck, recourse must be had to an auxiliary operation, called *punching*. See the embossing punches, *fig. 1138*. These are made of cast steel, with their hollows turned out in the lathe. The pieces *a, b* are of lead. The punching is performed by a series of these tools, of different sizes, beginning with the largest, and ending with the least. By this means a hollow cone, 3 or 4 inches deep, and an inch diameter, may be raised out of a flat plate. These punches are struck with a hand hammer also, for small articles, of too great delicacy for the drop. Indeed it frequently happens that one part of an article is executed by the stamp and another by the hand.

Cylindrical and conical vessels are mostly formed by bending and soldering. The bending is performed on blocks of wood, with wooden mallets; but the machine so much used by the tin-smiths, to form their tubes and cylindric vessels (see the end section *figs. 1139. & 1140.*), might be employed with advantage. This consists of 3 iron rollers fixed in an iron frame. *A, B, C*, are the three cylinders, and *a, b, c, d*, the riband or sheet of metal passed through them to receive the cylindrical or conical curvature. The upper roller *A* can be raised or lowered at pleasure, in order to modify the diameter of the tube; and when one end of the roller is higher than the other, the conical curvature is given. The edges of the plated cylinders or cones are soldered with an alloy composed of silver and brass. An alloy of silver and copper is somewhat more fusible; but that of brass and silver answers best for plated metal, the brass being in very small proportion, lest the colour of the plate be affected. Calcined borax mixed with sandiver (the salt skimmed from the pots of crown glass) is used along with the alloy, in the act of soldering. The seam of the plated metal being smeared with that saline mixture made into a pap with water, and the bits of laminated solder, cut small with scissors, laid on, the seam is exposed to the flame of an oil blowpipe, or to that of charcoal urged by bellows in a little forge-hearth, till the solder melts and flows evenly along the junction. The use of the sandiver seems to be, to prevent the iron wire that binds the plated metal tube from being soldered to it.

Mouldings are sometimes formed upon the edges of vessels, which are not merely ornamental, but give strength and stiffness. These are fashioned by an instrument called a *swage*, represented in *figs. 1141. & 1142.* The part *A* lifts up by a joint, and



the metal to be *swaged* is placed between the dies, as shown in the figures; the tail *b* being held in the jaws of a vice, while the shear-shaped hammer rests upon it. By striking on the head *A*, while the metal plate is shifted successively forwards, the beading is formed. In *fig. 1141*, the tooth *a* is a guide to regulate the distance between the bead and the edge. A similar effect is produced of late years in a neater and more expeditious manner by the rollers, *figs. 1142, 1143.* *Fig. 1145.* is a section to show the form of the bead. The two wheels *a, a*, *fig. 1143.*, are placed upon axes, two of which are furnished with toothed pinions in their middle; the lower one being turned by the

handle, gives motion to the upper. The groove in the upper wheel corresponds with the bead in the lower, so that the slip of metal passed through between them assumes the same figure.

The greatest improvement made in this branch of manufacture, is the introduction of silver edges, beads and mouldings, instead of the plated ones, which from their prominence had their silver surface speedily worn off, and thus assumed a brassy look. The silver destined to form the ornamental edging is laminated exceedingly thin; a square inch sometimes weighing no more than 10 or 12 grains. This is too fragile to bear the action of the opposite steel dies of the swage above described. It is necessary, therefore, that the sunk part of the die should be steel, and the opposite side lead, as was observed in the stamping; and this is the method now generally employed to form these silver ornaments. The inside shell of this silver moulding is filled with soft solder, and then bent into the requisite form.

The base of candlesticks is generally made in a die by the stamp, as well as the neck, the dish part of the nozzle or socket, and the tubular stem or pillar. The different parts are united, some with soft and others with hard solder. The branches of candlesticks are formed in two semi-cylindrical halves, like the feet of tea-urns. When an article is to be engraved on, an extra plate of silver is applied at the proper part, while the plate is still flat, and fixed by burnishing with great pressure over a hot anvil. This is a species of welding.

The last finish of plated goods is given by burnishing tools of bloodstone, fixed in sheet-iron cases, or hardened steel, finely polished.

The ingots for lamination might probably be plated with advantage by the delicate pressure process employed for silvering copper wire.

The total value of the plate, plated ware, jewellery, and watches, exported in the year 1836, was 338,889*l.*; but the value of the plated goods is not given in the tables of revenue. M. Parquin, the greatest manufacturer of plated goods in Paris (or France, for this business is monopolized by the capital), who makes to the value of 700,000 francs per annum, out of the 1,500,000 which, he says, is the whole internal consumption of that kingdom, states that the internal consumption of the United Kingdom amounts to 30,000,000, or 20 times that of France! He adds, that our common laminated copper costs 26 sous the pound, while theirs costs 34. Their plated goods are fashioned, not in general with stamps, but by the pressure of tools upon wood moulds in the turning-lathe (spinning), which is a great economy of capital to the manufacturer. There are factories at Birmingham which possess a heavy stock of 300,000 different die-moulds. The value of British made plate annually used in this country is estimated at 1,200,000*l.* The exports of plate amounted in 1849 to the value of 233,058*l.* See *STAMPING OF METALS*, and *ELECTROTYPE*.

PLATINUM MOHR. This interesting preparation, which so rapidly oxidizes alcohol into acetic acid, &c., by what has been called in chemistry the catalytic or contact action, is most easily prepared by the following process of M. Böttger:—the insoluble powder of potash-chlorure or ammonia-chlorure of platinum is to be moistened with sulphuric acid (oil of vitriol), and a bit of zinc is to be laid in the mixture. The platinum becomes reduced into a black powder, which is to be washed first with muriatic acid and then with water. The fineness of this powder depends upon that of the saline powders employed to make it; so that if these be previously finely ground, the platinum-mohr will be also very fine, and proportionally powerful as a chemical agent.

The following easy method of preparing igniferous black platinum, proposed thirty years ago by Descotil, has been recently recommended by M. Dobereiner:—

Melt platina ore with double its weight of zinc, reduce the alloy to powder, and treat it first with dilute sulphuric acid, and next with dilute nitric acid, to oxidize and dissolve out all the zinc, which, contrary to one's expectations, is somewhat difficult to do, even at a boiling heat. The insoluble black-gray powder contains some osmuret of iridium, united with the crude platinum. This compound acts like simple platina-black, after it has been purified by digestion in potash lye, and washing with water. Its oxidizing power is so great, as to transform not only the formic acid into the carbonic, and alcohol into vinegar, but even some osmic acid, from the metallic osmium. The above powder explodes by heat like gunpowder.

When the platina-mohr prepared by means of zinc is moistened with alcohol, it becomes incandescent, and emits osmic acid; but if it be mixed with alcohol into a paste, and spread upon a watch-glass, nothing but acetic acid will be disengaged; affording an elegant means of diffusing the odour of vinegar in an apartment. See *Berz.* i. 423.

Platinizing by the moist way. Manufacturing and operative chemists will find it exceedingly valuable in order to produce a covering of platina for their copper, &c., vessels. The experiment succeeds best when we make use of a dilute solution of the double chloride of soda and platina. Three immersions suffice; between each immersion it is necessary to dry the surface with fine linen, rubbing rather briskly, after which it

must be cleansed with levigated chalk before re-immersion. When copper has been gilded in the moist way, the surface has not a beautiful tint; but, if the copper be previously covered with a pellicle of platina, a very beautiful golden surface may be produced.

PLATINUM, is a metal of a grayish-white colour, resembling in a good measure polished steel. It is harder than silver, and of about double its density, being of specific gravity 21. It is so infusible, that no considerable portion of it can be melted by the strongest heats of our furnaces. It is unchangeable in the air and water; nor does a white heat impair its polish. The only acid which dissolves it, is the nitromuriatic; the muriate or chloride thus formed affords, with pure ammonia or sal-ammoniac, a triple salt in a yellow powder, convertible into the pure metal by a red heat. This character distinguishes platinum from every other metal.

Native Platinum, in the natural state is never pure, being alloyed with several other metals. It occurs only under the form of grains, which are usually flattened, and resemble in shape the gold *pepitas*. Their size is in general less than linseed, although in some cases they equal hempseed, and, occasionally, peas. One piece brought from Choco, in Peru, and presented to the Cabinet of Berlin, by M. Humboldt, weighs 55 grammes = 850 grains, or nearly 2 oz. avoirdupois. The greatest lump of native platinum known, till of late years, was one in the Royal Museum of Madrid, which was found in 1814 in the gold mine of Condoto, province of Novita, at Choco. Its size is greater than a Turkey's egg, (about 2 inches one diameter, and 4 inches the other,) and its weight 760 grammes, = 24 oz. or fully 2 lb. troy. See *infra*.

The colour of the grains of native platinum is generally a grayish white, like tarnished steel. The cavities of the rough grains are often filled with earthy and ferruginous matters, or sometimes with small grains of black oxide of iron, adhering to the surface of the platinum grains. Their specific gravity is also much lower than that of forged pure platinum; varying from 15 in the small particles, to 18.94 in M. Humboldt's large specimen. This relative lightness is owing to the presence of iron, copper, lead, and chrome; besides its other more lately discovered metallic constituents, palladium, osmium, rhodium, and iridium.

Its main localities in the New Continent are the three following districts:—

1. At Choco, in the neighbourhood of Barbacoas, and generally on the coasts of the South Sea, or on the western slopes of the Cordillera of the Andes, between the 2nd and the 6th degrees of north latitude. The gold-washings that furnish most platinum are those of Condoto, in the province of Novita; those of Santa Rita, or Viroviro, of Santa Lucia, of the ravine of Iro, and Apoto, between Novita and Taddo. The deposit of gold and platinum grains is found in alluvial ground, at a depth of about 20 feet. The gold is separated from the platinum by picking with the hand, and also by amalgamation; formerly, when it was imagined that platinum might be used to debase gold, the grains of the former metal were thrown into the rivers, through which mistaken opinion an immense quantity of it was lost.

2. Platinum grains are found in Brazil, but always in the alluvial lands that contain gold, particularly in those of Matto-Grosso. The ore of this country is somewhat different from that of Choco. It is in grains, which seem to be fragments of a spongy substance. The whole of the particles are nearly globular, exhibiting a surface formed of small spheroidal protuberances strongly cohering together, whose interstices are clean, and even brilliant.

This platinum includes many small particles of gold, but none of the magnetic iron-sand or of the small zircons which accompany the Peruvian ore. It is mixed with small grains of native palladium, which may be recognized by their fibrous or radiated structure, and particularly by their chemical characters.

3. Platinum grains are found in Hayti, or Saint Domingo, in the sand of the river Jacky, near the mountains of Sibao. Like those of Choco, they are in small brilliant grains, as if polished by friction. The sand containing them is quartzose and ferruginous. This native platinum contains, like that of Choco, chromium, copper, osmium, iridium, rhodium, palladium, and probably titanium. Vauquelin could find no gold among the grains.

Platinum has been discovered lately in the Russian territories, in the auriferous sands of Kuschwa, 250 wersts from Ekaterinebourg, and consequently in a geological position which seems to be analogous with that of South America.

These auriferous sands are, indeed, almost all superficial; they cover an argillaceous soil; and include, along with gold and platinum, debris of dolerite (a kind of greenstone), protoxide of iron, grains of corundum, &c. The platinum grains are not so flat as those from Choco, but they are thicker; they have less brilliancy, and more of a leaden hue. This platinum, by M. Laugier's analysis, is similar in purity to that of Choco; but the leaden-gray grains, which were taken for a mixture of osmium and iridium, are merely an alloy of platinum, containing 25 per cent. of these metals.

The mines of Brazil, Columbia, and Saint Domingo furnish altogether only about 400 kilos. of platinum ore per annum; but those of Russia produce above 1800 kilos.

The latter were discovered in 1822, and were first worked in 1824. They are all situated in the Ural mountains. The ore is disseminated in an argillaceous sand, of a greenish gray colour, resulting from the disintegration of the surrounding rocks, and constitutes from 1 to 3 parts in 4000 of the sand. Occasionally it has been found in lumps weighing 8 kilogrammes (16 lbs.), but it generally occurs in blackish angular grains, which contain 70 per cent. of platinum, and 3 to 5 of iridium. The ore of Goro-Blagodat is in small flattened grains, which contain 88 per cent. of this precious metal. The osmiure of iridium is found upon a great many points in the Urals, throughout a space of 140 leagues, being a product accessory to the gold washings. 32 kilogrammes of osmiure are collected there annually, which contain upon an average 2 per cent. of platinum.

M. Vauquelin found nearly 10 per cent. of platinum in an ore of argentiferous copper, which was transmitted to him as coming from Guadalcanal in Spain. This would be the only example of platinum existing in a rock, and in a vein. As the same thing has not again been met with, even in other specimens from Guadalcanal, we must delay drawing geological inferences, till a new example has confirmed the authenticity of the first.

Platinum has been known in Europe only since 1748, though it was noticed by Ulloa in 1741. It was compared at first to gold; and was, in fact, brought into the market under the name of white gold. The term platinum, however, is derived from the Spanish word, *plata*, silver, on account of its resemblance in colour to that metal.

The whole of the platinum ore from the Urals is sent to St. Petersburg, where it is treated by the following simple process:—

One part of the ore is put in open platina vessels, capable of containing from 6 to 8 lbs., along with 3 parts of muriatic acid at 25° B. and 1 part of nitric acid at 40°. Thirty of these vessels are placed upon a sand-bath covered with a glazed dome with movable panes, which is surmounted by a ventilating chimney to carry the vapours out of the laboratory. Heat is applied for 8 or 10 hours, till no more red vapours appear; a proof that the whole nitric acid is decomposed, though some of the muriatic remains. After settling, the supernatant liquid is decanted off into large cylindrical glass vessels, the residuum is washed, and the washing is also decanted off. A fresh quantity of nitro-muriatic acid is now poured upon the residuum. This treatment is repeated till the whole solid matter has eventually disappeared. The ore requires for solution from 10 to 15 times its weight of nitro-muriatic acid, according to the size of its grains.

The solutions thus made are all acid; a circumstance essential to prevent the iridium from precipitating with the platinum, by the water of ammonia, which is next added. The deposit being allowed to form, the mother waters are poured off, the precipitate is washed with cold water, dried, and calcined in crucibles of platinum.

The mother-waters and the washings are afterwards treated separately. The first being concentrated to one-twelfth of their bulk in glass retorts, on cooling they let fall the iridium in the state of an ammoniacal chloride, constituting a dark-purple powder, occasionally crystallised in regular octahedrons. The washings are evaporated to dryness in porcelain vessels; the residuum is calcined and treated like fresh ore; but the platinum it affords needs a second purification.

For agglomerating the platinum, the spongy mass is pounded in bronze mortars; the powder is passed through a fine sieve, and put into a cylinder of the intended size of the ingot. The cylinder is fitted with a rammer, which is forced in by a coining press, till the powder be much condensed. It is then turned out of the mould, and baked 36 hours in a porcelain kiln, after which it may be readily forged, if it be pure, and may receive any desired form from the hammer. It contracts in volume from 1-6th to 1-5th during the calcination. The cost of the manufacture of platinum is fixed by the administration at 39 francs the Russian pound; but so great a sum is never expended upon it.

For Dr. Wollaston's process, see *Phil. Trans.* 1829, Part I.

Platinum furnishes most valuable vessels to both analytical and manufacturing chemists. It may be beat out into leaves of such thinness as to be blown about with the breath.

This metal is applied to porcelain by two different processes; sometimes in a rather coarse powder, applied by the brush, like gold, to form ornamental figures; sometimes in a state of extreme division, obtained by decomposing its muriatic solution, by means of an essential oil, such as rosemary or lavender. In this case, it must be evenly spread over the whole ground. Both modes of application give rise to a steely lustre.

The properties possessed in common by gold and platinum have several times given occasion to fraudulent admixtures, which have deceived the assayers. M. Vauquelin having executed a series of experiments to elucidate this subject, drew the following conclusions:—

If the platinum do not exceed 30 or 40 parts in the thousand of the alloy, the gold does not retain any of it when the parting is made with nitric acid in the usual way; and when the proportion of platinum is greater, the fraud becomes manifest, 1st, by the higher temperature required to pass it through the cupel, and to form a round button; 2, by the absence of the lightning, fulguration, or coruscation; 3, by the dull white colour of the button and its crystallized surface; 4, by the straw-yellow colour which platinum communicates to the aquafortis in the parting; 5, by the straw-yellow colour, bordering on white, of the cornet, after it is annealed. If the platinum amounts to one fourth of the gold, we must add to the alloy at least 3 times its weight of fine silver, laminate it very thin, anneal somewhat strongly, boil it half an hour in the first aquafortis, and at least a quarter of an hour in the second, in order that the acid may dissolve the whole of the platinum.

Were it required to determine exactly the proportions of platinum contained in an alloy of copper, silver, gold, and platinum, the amount of the copper may be found in the first place by *cupellation*, then the respective quantities of the three other metals may be learned by a process founded, 1, upon the property possessed by sulphuric acid of dissolving silver without affecting gold or platinum; and, 2, upon the property of platinum being soluble in the nitric acid, when it is alloyed with a certain quantity of gold and silver.

According to Bousingault, the annual product of platinum in America does not exceed 8½ cwts. At Nischne-Tagilsk, in 1824, a lump of native platinum weighing fully 10 lbs. was found; and in 1830, another lump, of nearly double size, which weighed 35½ Prussian marcs; fully 18 lbs. avoirdupoise. Beds of platinum occur about 12 vers W.N.W. of Chertoistischinsk, and a richer bed has been recently worked at the source of the Tramganka.

PRODUCTION OF PLATINUM IN THE URAL.

| | | | |
|--------------------------------|-----------------------|-----|-------------|
| From 1822 to 1827 inclusively, | 52 pud ^s * | and | 22½ pounds. |
| 1828 | 94 | | |
| 1829 | 78 | | 31½ |
| 1830 | 105 | | 1 |
| 1831 to 1833 | 348 | | 15 |

ANALYSES of the PLATINUM ORES of the Urals, and of that from Barbacoas on the Pacific between the 2nd and 6th degrees of northern latitude.

| | From Nischne-Tagilsk. Berzelli. | | Goroblagodat. Osann. | | Barbacoas. Berzelli. |
|-------------|------------------------------------|---------------|-------------------------|-------|-------------------------|
| | Magnetic. | Not Magnetic. | | | |
| Platinum - | 73.58 | 78.94 | 83.07 | 86.50 | 84.30 |
| Iridium - | 2.35 | 4.97 | 1.91 | — | 1.46 |
| Rhodium - | 1.15 | 0.86 | 0.59 | 1.15 | 3.46 |
| Palladium - | 0.30 | 0.28 | 0.26 | 1.10 | 1.06 |
| Iron - | 12.98 | 11.04 | 10.79 | 8.32 | 5.31 |
| Copper - | 5.20 | 0.70 | 1.30 | 0.45 | 0.74 |
| Undissolved | | | | | |
| Osmium and | 2.30 | 1.96 | 1.80 | 1.40 | — |
| Iridium | | | | | |
| Osmium - | — | — | — | — | 1.03 |
| Quartz - | — | — | — | — | 0.60 |
| Lime - | — | — | — | — | 0.12 |
| | 97.86 | 98.75 | 99.72 | 98.92 | 98.08 |

PLUMBAGO. See GRAPHITE, for its mineralogical and chemical characters. The mountain at Borrowdale, in which the blacklead is mined, is 2000 feet high, and the entrance to the mine is 1000 feet below its summit. This valuable mineral became so common a subject of robbery about a century ago, as to have enriched, it was said, a great many persons living in the neighbourhood. Even the guard stationed over it by the proprietors was of little avail against men infuriated with the love of plunder; since in those days a body of miners broke into the mine by main force, and held possession of it for a considerable time.

The treasure is now protected by a strong building, consisting of four rooms upon the ground floor; and immediately under one of them is the opening, secured by a trap-door, through which alone workmen can enter the interior of the mountain. In this apartment, called the dressing-room, the miners change their ordinary clothes for their

* One pud=40 Russian pounds=69,956 Prussian marcs, (see SILVER); 1 pound=96 solotniks.

working dress, as they come in, and after their six hours' post or journey, they again change their dress, under the superintendence of the steward, before they are suffered to go out. In the innermost of the four rooms, two men are seated at a large table sorting and dressing the plumbago, who are locked in while at work, and watched by the steward from an adjoining room, who is armed with two loaded blunderbusses. Such formidable apparatus of security is deemed requisite to check the pilfering spirit of the Cumberland mountaineers.

The cleansed blacklead is packed up into strong casks, which hold 1 cwt. each. These are all despatched to the warehouse of the proprietors in London, where the blacklead is sold monthly by auction, at a price of from 35s. to 45s. a pound, and upwards.

In some years, the net produce of the six weeks' annual working of the mine has, it is said, amounted to 30,000L or 40,000L.

PLUSH (*Pusse, Peluche, Fr.*; *Wollsammet, Plüsch, Germ.*), is a textile fabric, having a sort of velvet nap or shag upon one side. It is composed regularly of a woof of a single woollen thread, and a two-fold warp, the one, wool of two threads twisted, the other, goat's or camel's hair. There are also several sorts of plush made entirely of worsted. It is manufactured, like velvet, in a loom with three treadles; two of which separate and depress the woollen warp, and the third raises the hair-warp, whereupon the weaver, throwing the shuttle, passes the wool between the woollen and hair warp; afterwards, laying a brass brooch or needle under that of the hair, he cuts it with a knife (see *FUSTIAN*) destined for that use, running its fine slender point along in the hollow of the guide-brooch, to the end of a piece extended upon a table. Thus the surface of the plush receives its velvety appearance. This stuff is also made of cotton and silk.

POINT NET, is a style of lace formerly much in vogue, but now superseded by the bobbin-net manufacture.

POLYCHROMATE (*Polychromate, or chrysammic acid*), a new compound from which a variety of colours may be prepared.

Chrysammic acid, if such be the acid here alluded to, has been known hitherto only to the chemist as the result of the action of nitric acid upon powdered aloes. Obtained by this process, chrysammic acid appears in golden crystals. The salts of compounds of this acid are remarkable for their brilliancy of colour; but their application in the arts is perfectly new.

PORCELAIN, is the finest kind of pottery-ware. It is considered under that title.

The articles in the Exhibition under the head Statuary Porcelain, including Parian, Carrara, &c., are produced by "casting." As the most direct method of illustrating this process, let us suppose the object under view to be a figure or group, and this we will assume to be 2 feet high in the model. The clay which is used in a semi-liquid state about the consistency of cream and called "slip," is poured into the moulds forming the various parts of the subject, (sometimes as many as fifty): the shrinking that occurs before these casts can be taken out of the mould, which is caused by the absorbent nature of the plaster of which the mould is composed, is equal to a reduction of one inch and a half in the height. These casts are then put together by the "figure-maker," the seams (consequent upon the marks caused by the subdivisions of the moulds) are then carefully removed, and the whole worked upon to restore the cast to the same degree of finish as the original model. The work is then thoroughly dried to be in a fit state for firing, as if put in the oven while damp the sudden contraction consequent upon the great degree of heat instantaneously applied, would be very liable to cause it to crack; in the process it again suffers a further loss of one inch and a half by evaporation, and it is now but 1 foot 9 inches. Again in the "firing" of the bisque oven, its most severe ordeal, it is diminished 3 inches, and is then but 18 inches high, being 6 inches or one fourth less than the original. Now as the contraction should equally affect every portion of the details of the work, in order to realize a faithful copy, and as added to this contingency are the risks in the oven of being "over-fired," by which it would be melted into a mass, and of being "short-fired," by which its surface would be imperfect, it is readily evident that a series of difficulties present themselves which require considerable practical experience successfully to meet. The moulds are made of plaster of Paris, which, when properly prepared, has the property of absorbing water so effectually that the moisture is extracted from the clay, and the ware is enabled to leave the mould, or "deliver" with care and rapidity. Prior to use the plaster (gypsum) is put into long troughs, having a fire running underneath them, by which means the water is drawn off, and it remains in a state of soft powder; and if its own proportion of water be again added to it, it will immediately set into a firm compact body, which is the case when it is mixed to form the mould.

The following are the degrees of temperature in which the different branches work:—

| | | | | | |
|------------------------|---|---|---|---|------------|
| Plate-makers' hothouse | - | - | - | - | 108° Fahr. |
| Dish-makers' hothouse | - | - | - | - | 106 " |
| Printers' shop | - | - | - | - | 90 " |
| Throwers' hothouse | - | - | - | - | 98 " |

The branches against which the temperature of the hothouse is placed, require that heat for drying their work and getting it off their moulds. The outer shops in which they work may be from five to ten degrees less.

Variety of vases, garden pots, and articles of ordinary use.

Ancient font, from the original in Winchester Cathedral.

The Portland jug. Lily of the valley jug. The scanthus garden vase.

Fine porcelain.

A vase of Etruscan form, with chased and burnished gold ornaments on a blue ground, decorated with floral wreaths enamelled, in colours, &c., with pedestal of 40 inches high.

A variety of ornamental vases, chased and gilded with various designs and otherwise.

Verulam bottles, ribbon wreath, and group of flowers, turquoise ribbon, and group of flowers; and gold lattice.

Large tripod for flower stand, blue ground decorated in chased and burnished gold.

The Dove tazze and pedestal. The birds and embossments in solid gold, chased turquoise ground and floral wreath, &c. Another with royal blue grounds, the details of ornament in gold and silver.

Enamel colours are metallic oxides incorporated with a fusible flux; gold precipitated by tin furnishes the crimson, rose, and purple; oxides of iron and chrome produce reds; the same oxides yield black and brown, also obtained from manganese and cobalt; orange is from oxides of uranium, chrome, antimony, and iron; greens from oxides of chrome and copper; blue from oxides of cobalt and zinc. The fluxes are borax, flint, oxides of lead, &c. They are worked in essential oils and turpentine, and a very great disadvantage under which the artist labours, is that the tints upon the palette are in most cases different to those they assume when they have undergone the necessary heat, which not only brings out the true colour, but also, by partially softening the glaze and the flux, causes the colour to become fixed to the ware. This disadvantage will be immediately apparent in the case where a peculiar delicacy of tint is required, as in flesh stones for instance. But the difficulty does not end here, for as a definite heat can alone give to a colour a perfect hue, and as the colour is continually varying with the different stages of graduated heat, another risk is incurred, that resulting from the liability of its receiving the heat in a greater or less degree, termed "over-fired" and "short-fired." As an instance of its consequence, we cite rose colour or crimson, which when used by the painter is a dirty violet or drab; during the process of firing it gradually varies with the increase of heat from a brown to a dull reddish hue, and from that progressively to its proper tint. But if by want of judgment or inattention of the fireman the heat is allowed to exceed that point, the beauty and brilliancy of the colour are destroyed beyond remedy, and it becomes a dull purple. On the other hand, should the fire be too slack, the colour is presented in one of its intermediate stages, as already described, but in this case extra heat will restore it. Nor must we forget to allude to casualties of cracking and breaking in the kilns by the heat being increased or withdrawn too suddenly, a risk to which the larger articles are peculiarly liable. These vicissitudes render enamel painting in its higher branches a most unsatisfactory and disheartening study, and enhance the value of those productions which are really successful and meritorious.

There are two distinct methods of printing in use for china and earthenware, one is transferred on the bisque, and is the method by which the ordinary printed ware is produced, and the other is transferred on the glaze. The first is called "press printing" and the latter "bat printing." The engraving is executed upon copper plates, and for press printing is cut very deep to enable it to hold a sufficiency of colour to give a firm and full transfer to the ware. The printer's shop is furnished with a brisk stove having an iron plate on the top immediately over the fire, for the convenience of warming the colour while being worked, also a roller press and tubs. The printer has two female assistants called "transferers," and also a girl called a "cutter." The copper plate is charged with colour mixed with thick boiled oil by means of a knife and "dabber," while held on the hot stove plate for the purpose of keeping the colour fluid; and the engraved portion being filled, the superfluous colour is scraped off the surface of the copper by the knife, which is further cleaned by being rubbed with a boss made of leather. A thick firm oil is required to keep the different parts of the design from flowing into a mass or becoming confused while under the pressure of the rubber, in the process of transferring. A sheet of paper of the necessary size and of a peculiarly thin texture, called "pottery tissue," after being saturated with a thin solution of soap and water, is placed upon the copper plate, and being put under the action of the press, the paper is carefully drawn off again, (the engraving being placed on the stove,) bringing with it the colour by which

the plate was charged constituting the pattern. This impression is given to the "cutter," who cuts away the superfluous paper about it; and if the pattern consists of a border and a centre the border is separated from the centre, as being more convenient to fit to the ware when divided. It is then laid by a transferer upon the ware and rubbed first with a small piece of soaped flannel to fix it, and afterwards with a rubber formed of rolled flannel. This rubber is applied to the impression very forcibly, the friction causing the colour to adhere firmly to the bisque surface, by which it is partially imbibed; it is then immersed in a tub of water, and the paper washed entirely away with a sponge, the colour, from its adhesion to the ware and being mixed with oil, remaining unaffected. It is now necessary, prior to "glazing," to get rid of this oil, which is done by submitting the ware to heat in what are called "hardening kilns," sufficient to destroy it and leave the colour pure. This is a necessary process, as the glaze, being mixed with water, would be rejected by the print, while the oil remained in the colour.

The "bat printing" is done upon the glaze, and the engravings are for this style exceedingly fine, and no greater depth is required than for ordinary book engravings. The impression is not submitted to the heat necessary for that in the bisque, and the medium of conveying it to the ware is also much purer. The copper plate is first charged with linseed oil, and cleaned off by hand, so that the engraved portion only retains it. A preparation of glue being run upon flat dishes about a quarter of an inch thick, is cut to the size required for the subject, and then pressed upon it, and being immediately removed, draws on its surface the oil with which the engraving was filled. The glue is then pressed upon the ware, with the oiled part next the glaze, and being again removed, the design remains; though, being in a pure oil, scarcely perceptible. Colour finely ground is then dusted upon it with cotton wool, and a sufficiency adhering to the oil leaves the impression perfect, and ready to be fired in the enamel kilns.

We shall refer in the first place to the preparation of the two principal ingredients, flint and natural clay for the use of the potter, and afterwards to the blending of them. The flint stones are first calcined, and this is effected in a kiln similar to that used for lime burning. These stones are separated by alternate layers of coal, and the burning usually occupies about 24 hours. The flints are then very white and very brittle, and ready to be crushed by the "stamper," a machine composed of upright shafts of wood, 6 feet long and about 8 inches square, heavily loaded with iron at the lower end, which, by means of applied power, are made to rise and fall in succession on the flints, contained in a strong grated box. It is then removed to the grinding vats, which are from 12 to 14 feet in diameter, and 4 feet deep, paved with chert stone, large blocks of which being also worked round by arms connected with a central vertical shaft, propelled by an engine, become a powerful grinding medium. This peculiar stone is used because of its chemical affinity to the fluid, which therefore suffers no deterioration from the mixture of the abraded particles, which necessarily result from the friction, a matter of serious moment. In these vats the fluid is ground in water, until it attains the consistency of thick cream, when it is drawn off and conveyed by troughs into the washing chamber. Here it undergoes a further purification, more water is added, and it is kept in a state of gentle agitation by means of revolving arms of wood, thus keeping the finer particles in suspension while the liquid is again drawn away in pipes to a tank below. The sediment is afterwards reground.

The cleansing process is not yet complete, for when the fluid has passed into these tanks to about half their depth, they are filled up with water, which is repeatedly changed, until it is considered sufficiently fine and free from all foreign matters; it is then fit for use. The clay requires no grinding. It is received from the merchants prepared, and has merely to be mixed with water till it attains the same degree of fluidity as the flints. The next stage is the "mixing," for which purpose the different "slips" (the technical term for the fluid clays, &c.) are successively run off into the blending reservoir, against the inner side of which are "gauging rods," by which the necessary proportion of each material is regulated. The mixture is now passed into other reservoirs, through fine sieves, on "lawns" woven of silk, and containing 300 threads to the square inch. A pint of slip of Dorsetshire or Devonshire clay weighs 24 ounces, of proper consistence; of Cornish clay 26 ounces; and of flint 32 ounces. Finally the slip is conveyed to a series of large open kilns heated underneath by means of flues, and about 9 inches deep. The excessive moisture is thus evaporated, and in about 24 hours the mixture becomes tolerably firm in substance. It is then cut into large blocks and conveyed to an adjoining building to undergo the process of "milling." The mill is in the form of a hollow cone inverted, with a square aperture or tube at the lower part. In the centre is a vertical shaft set with broad knives. When this shaft is in action (worked by steam power), the soft clay is thrown downwards, being alternately cut and pressed until it exudes from the aperture at the bottom in a perfectly plastic state, and ready for the hand of the potter.

In enamelling, ground-laying is the first process in operating on all designs to which it is applied; it is extremely simple, requiring principally lightness and delicacy of

hand. A coat of boiled oil adapted to the purpose being laid upon the ware with a pencil, and afterwards levelled, or as it is technically termed "bossed," until the surface is perfectly uniform; as the deposit of more oil on one part than another would cause a proportionate increase of colour to adhere, and consequently produce a variation of tint. This being done, the colour, which is in a state of fine powder, is dusted on the oiled surface with cotton wool; a sufficient quantity readily attaches itself, and the superfluity is cleared off by the same medium. If it be requisite to preserve a panel ornament or any object white upon the ground, an additional process is necessary, called "stencilling." The stencil (generally a mixture of rose-pink, sugar, and water) is laid on in the form desired with a pencil, so as entirely to protect the surface of the ware from the oil, and the process of "grounding," as previously described, ensues. It is then dried in an oven to harden the oil and colour, and immersed in water, which penetrates to the stencil, and, softening the sugar, is then easily washed off, carrying with it any portion of colour or oil that may be upon it, and leaving the ware perfectly clean. It is sometimes necessary, where great depth of colour is required, to repeat these colours several times. The "ground-layers" do generally, and should always, work with a bandage over the mouth to avoid inhaling the colour-dust, much of which is highly deleterious. Bossing is the term given to the process by which the level surfaces of various colours so extensively introduced upon decorated porcelain are effected. The "boss" is made of soft leather.

The process of gilding is as follows:—The gold (which is prepared with quicksilver and flux) when ready for use, appears a black dust; it is used with turpentine and oils similar to the enamel colours, and like them worked with the ordinary camels' hair pencil. It flows very freely, and is equally adapted for producing broad massive bands and grounds, or the finest details of the most elaborate design.

To obviate the difficulty and expense of drawing the pattern on every piece of a service, when it is at all intricate, a "pounce" is used, and the outline dusted through with charcoal,—a method which also secures uniformity of size and shape. Women are precluded from working at this branch of the business, though from its simplicity and lightness it would appear so well adapted for them. Firing restores the gold to its proper tint, which first assumes the character of "dead gold," its after brilliancy being the result of another process termed "burnishing."

The process of bisque firing is as follows: the ware being finished from the hands of the potter is brought by him upon boards to the "green-house," so called from its being the receptacle for ware in the "green" or unfired state. It is here gradually dried for the ovens; when ready it is carried to the "sagger-house" in immediate connection with the oven in which it is to be fired, and here it is placed in the "saggers:" these are boxes made of a peculiar kind of clay (a native marl) previously fired, and infusible at the heat required for the ware, and of form suited to the articles they are to contain. A little dry pounded flint is scattered between them of china, and sand of earthenware to prevent adhesion. The purpose of the sagger is to protect the ware from the flames and smoke, and also for its security from breakage, as in the clay state it is exceedingly brittle, and when dry, or what is called white, requires great care in the handling. A plate sagger will hold twenty plates placed one on the other of earthenware, but china plates are fired separately in "setters" made of their respective forms. The "setters" for china plates and dishes answer the same purpose as the saggers, and are made of the same clay. They take in one dish or plate each, and are "reared" in the oven in "bungs," one on the other.

The hovels in which the ovens are built form a very peculiar and striking feature of the pottery towns, and forcibly arrest the attention and excite the surprise of the stranger, resembling as they closely do a succession of gigantic bee-hives. They are constructed of bricks about 40 feet in diameter, and about 35 feet high, with an aperture at the top for the escape of the smoke. The "ovens" are of a similar form, about 22 feet diameter, and from 18 to 21 feet high, heated by fire-places or "mouths," about nine in number, built externally around them. Flues in connection with these converge under the bottom of the oven to a central opening, drawing the flames to this point, where they enter the oven; other flues termed "bags" pass up the internal sides to the height of about 4 feet, thus conveying the flames to the upper part.

When "setting in" the oven, the firemen enter by an opening in the side, carrying the saggers with the ware placed as described; these are piled one upon another, from bottom to top of the oven, care being taken to arrange them so that they may receive the heat (which varies in different parts) most suited to the articles they contain. This being continued till the oven is filled, the aperture is then bricked up. The firing of earthenware bisque continues sixty hours, and of china forty-eight.

The quantity of coals necessary for a "bisque" oven is from 16 to 20 tons; for a "glost" oven from 4½ to 6 tons.

The ware is allowed to cool for two days, when it is drawn in the state technically called "biscuit" or bisque, and is then ready for "glazing," except when required for

printing or a common style of painting, both of which processes are done on the bisque prior to being "glazed."

A large proportion of circular articles not requiring ornament or relief beyond plain curved surfaces are "thrown and turned." Few are unacquainted with the wonder-working powers of the potter's wheel. A ball of clay is placed on the centre of the revolving block, and by the simplest manipulation is made to spring at once into form and character, assuming at the operator's will any contour of which a circular vessel is capable, the plastic clay being formed or transformed with an ease and rapidity almost incredible. Every piece, when made, is cut off the block by a wire being passed under it.

When the "thrown ware" is sufficiently dry, it is transferred to the hands of the "turner," whose province it is to form the curves more truly and sharply, and to impart a uniform smoothness and polish to the surface. This process resembles that of ordinary wood turning, but from the nature of the material is executed with much greater facility. The vessel is fitted upon a block or "churn" attached to the lathe, and the turning is performed by thin iron tools few in number and simple in form.

Articles of this class which require handles are passed from the lathe to the "handler." These useful adjuncts are made by pressure in moulds of plaster of Paris, and after being sufficiently dried, are fixed on the vessel with "slip." The adhesion is so immediate that in most cases the article may be lifted up by the handle before it has left the hand of the operator. When the handle is fitted, the superfluous slip which exudes from the junction after the parts have been pressed together, is removed with a sponge, and the surfaces worked together, and smoothed round with a small tool; the article is then finished unless a "spout" or lip is required, as in the case of teapots, jugs, &c. These are made and attached in the same manner as handles.

New compositions for glazing earthenware.—The materials comprised in the various glazes commonly used for china and earthenware, are Cornish stone, flint, white lead, glass, whiting, &c. These having been ground together in proper proportions to the consistence of milk form the glaze. The process is effected in large buildings termed "dipping-houses," (china and earthenware being kept separate) fitted up with tubes for the glaze, and stages for the reception of the ware when dipped, upon which it is dried and heated, generally by means of a large iron stove or "cockle," from which iron pipes extending in various directions convey the heat throughout the whole extent of the "houses." Each dipper is provided with a tub of glaze, in which he immerses the bisque ware. We may note the results of practice and experience in imparting a facility and dexterity of handling so necessary to perfection in this process. The ware is held so that as small a portion as possible shall be covered by the fingers; it is then plunged in the glaze, which by a dexterous jerk is made not only to cover the entire piece, but at the same time so disperses it, that an equal and level portion is disposed over the whole surface, which, being porous, imbibes and retains it. The ware is handed to the dipper by a boy, and another removes it when dipped to the drying or "hot-house." The glaze is opaque till fired, so that the design of pattern executed on the bisque is completely hid after dipping till they have been submitted to the glost fire. An able workman will dip about 700 dozen plates in a day.

In 1751 Dr. Wale established a manufactory in Worcester under the name of the "Worcester Porcelain Company," and to him appears to be due the idea of printing upon porcelain, the transferring of printed patterns to biscuit ware as usually adopted. From a magazine in the Museum of Practical Geology decorated with a portrait of Frederick the Great, the date of this process appears to be 1757.

The original Worcester Company principally confined themselves to making blue and white ware in imitation of that of Nankin, and in producing copies of the Japanese pottery.

Cockworthy of Plymouth appears to have carried on the business of a potter in Worcester until 1783, when the manufactory passed into the possession of Mr. Thomas Flight.

Stone china differs from the "tender porcelain," as the English ware is termed, in being a fused body; the alkali of the clays employed being by the heat of the furnace made to combine with the silica and alumina. Enamel colours are such as consist of metallic oxides combined with an alkaline flux, which, when exposed to a high temperature, forms a perfect glass.

When the ware leaves the hands of the painters, gilders, &c., it is carried to a receiving-room in connexion with the "enamel-kilns." The firemen select the ware from this room, according to the degree of heat they may require, and place it in that part of the kiln most likely to secure it. The different articles are ranged upon stages constructed of "slabs" or "bats" supported on props all made of fired clay. The time of firing is from 6 to 7 hours according to the size of the kiln, and whether it contains any articles of unusual size and hazard, in which case the heat is brought forward very gradually. The "ground-laying" being executed with colours less fusible than those

employed by the painters, the ware so decorated is fired in separate kilns at a higher temperature, a level glossy surface being a great desideratum; and as gold is often used in relief upon the "grounds," it would be liable to sink and lose its lustre unless the under colour had received a greater degree of heat than is required by the gilding. The kilns are built of large fired clay slabs made expressly for the purpose. They are about 3 feet 6 inches wide, 7 feet 6 inches high, and 6 feet 6 inches long, with circular tops, having flues beneath and around them. The fire-places or "mouths" are at the sides, and the flames, passing through the flues, encircle the kiln externally. Great care is taken to prevent the admission of smoke or flame into the body of the kilns, the fronts of which are closed with iron doors having in them small apertures, through which the firemen occasionally draw "trails" of colour made upon small pieces of ware, and thus ascertain to a certain extent the progress of the heat. This is a material assistance, but being drawn from one part only, still leaves a task requiring great care and nicety of judgment to manage successfully. Gold, if not sufficiently fired, will wipe off, and if over fired will not "burnish," and the gilding has to be repeated.

Penthesilea, Queen of the Amazons, slain, supported by Achilles. Thymbrean Apollo and Cassandra. Iris and Alceæ. The class of work to which these examples belong may be ranked under the head of Reproductive Art. The historical, mythical, and domestic events which they illustrate form vivid and instructive records of the manners and customs of the ancients. The original bases which have formed the material in this series are amongst the earliest memorial of Hellenic civilization. The date of their production extends from the second to the fifth century of the Christian era. The diversity and elegance of their forms bear conclusive evidence of the grace and beauty with which a refined and cultivated intelligence can mould the objects which minister to the humble and familiar purposes of household wants.

Their application was chiefly to domestic requirements; and it being a custom connected with the rite of burial to deposit within the sepulchre such objects as the deceased had most highly valued during life, the interment of a large number of these mortuary treasures, which so graphically illustrate Greek art and life, resulted. To this we owe the preservation of so interesting and numerous a series of these valuable mementos of archaic taste and skill. They are composed of red clay, the figure and ornamental composition being executed on a dark liquid pigment, worked in quick-drying oils, and submitted to a considerable degree of heat, to secure effectual adhesion. Amongst the earliest designs are placed these in which the black silhouette-like figures are painted upon the red or buff ground. These vases with the figures and ornaments in red on a black ground mark the period when Greek art was at its zenith.

In reference to the forms of these vases it may be instructive to remark that a careful analysis of the best examples in the British Museum proves that every curve is the segment of a circle; and it has been mathematically demonstrated that even in instances where the most irregular diversity of outline has been presented, that every curve has been circular and none elliptical.

PORPHYRY, is a compound mineral or rock, composed essentially of a base of hornstone, interspersed with crystals of felspar. It frequently contains also quartz, mica, and hornblende. That most esteemed is the ancient porphyry of Egypt, with a ground of a fine red colour passing into purple, having snow-white crystals of felspar imbedded in it. Most beautiful specimens of it are to be seen in the antique colossal statues in the British Museum.

Porphyry occurs in Arran, and in Perthshire between Dalnacardoch and Tummel bridge. It is much used for making slabs, mullers, and mortars.

PORTER, is a malt liquor, so called from being the favourite beverage of the porters and workpeople of the metropolis and other large towns of the British empire; it is characterized by its dark-brown colour, its transparency, its moderately bitter taste, and peculiar aromatic flavour, which, along with its tonic and intoxicating qualities, make it be keenly relished by thirsty palates accustomed to its use. At first the essential distinction of porter arose from its wort being made with highly-kilned brown-malt, while other kinds of beer and ale were brewed from a paler article; but of late years, the taste of the public having run in favour of sweeter and lighter beverages, the actual porter is brewed with a less proportion of brown malt, is less strongly hopped, and not allowed to get hard by long keeping in huge ripening tuns. Some brewers colour the porter with burnt sugar; but in general the most respectable concentrate a quantity of their first and best wort to an extract, in an iron pan, and burn this into a *colouring* stuff, whereby they can lay claim to the merit of using nothing in their manufacture but malt and hops. The singular flavour of good London porter seems to proceed, in a great degree, from that of the old casks and fermenting tuns in which it is prepared. Though not much addicted to vinous potations of any kind, I feel warranted by long experience to opine, that the porter brewed by the eminent London houses, when drunk in moderation, is a far wholesomer beverage for the people than the thin acidulous wines of France and Germany. See **BEER**.

PORTLAND CEMENT, is formed by calcining together limestone and some argillaceous earth, the result being a mass which most rapidly absorbs a certain quantity of water, and then becomes solid as a hydrous silicate of lime. The advantages over natural hydraulic limes consist generally in greater hardness and durability, arising from the mixture of material being more perfectly under command. Bricks cemented together by it bear a pressure on the outermost brick of 3 tons; being a beam of cement. A block of this cement tested by the hydraulic press bore a pressure of 250 tons.

PORTLAND STONE, is a fine compact oolite, so named from the island where it is quarried. It is a convenient but not a durable building-stone.

POTASH or POTASSA. (*Potasse*, Fr.; *Kali*, Germ.) This substance was so named from being prepared for commercial purposes by evaporating in iron pots the lixivium of the ashes of wood fuel. In the crude state called potashes, it consists, therefore, of such constituents of burned vegetables as are very soluble in water, and fixed in the fire. The potash salts of plants which originally contained vegetable acids, will be converted into carbonates, the sulphates will become sulphites, sulphurets, or even carbonates, according to the manner of incineration; the nitrates will be changed into pure carbonates, while the muriates or chlorides will remain unaltered. Should quicklime be added to the solution of the ashes, a corresponding portion of caustic potassa will be introduced into the product, with more or less lime, according to the care taken in decanting off the clear lye for evaporation.

In America, where timber is in many places an incumbrance upon the soil, it is felled, piled up in pyramids, and burned, solely with a view to the manufacture of potashes. The ashes are put into wooden cisterns, having a plug at the bottom of one of the sides under a false bottom; a moderate quantity of water is then poured on the mass, and some quicklime is stirred in. After standing for a few hours, so as to take up the soluble matter, the clear liquor is drawn off, evaporated to dryness in iron pots, and finally fused at a red heat into compact masses, which are gray on the outside, and pink-coloured within.

Pearlash is prepared by calcining potashes upon a reverberatory hearth, till the whole carbonaceous matter, and the greater part of the sulphur, be dissipated; then lixiviating the mass, in a cistern having a false bottom covered with straw, evaporating the clear lye to dryness in flat iron pans, and stirring it towards the end into white lumpy granulations.

I find the best pink Canadian potashes, as imported in casks containing about 5 cwts., to contain pretty uniformly 60 per cent. of absolute potassa; and the best pearlashes to contain 50 per cent.; the alkali in the former being nearly in a caustic state; in the latter, carbonated.

All kinds of vegetables do not yield the same proportion of potassa. The more succulent the plant, the more does it afford; for it is only in the juices that the vegetable salts reside, which are converted by incineration into alkaline matter. Herbaceous weeds are more productive of potash than the graminiferous species, or shrubs, and these than trees; and for a like reason twigs and leaves are more productive than timber. But plants in all cases are richest in alkaline salts when they have arrived at maturity. The soil in which they grow also influences the quantity of saline matter.

The following TABLE exhibits the average product in potassa of several plants, according to the researches of Vauquelin, Pertuis, Kirwan, and De Saussure:—

| In 1000 parts. | Potassa. | In 1000 parts. | Potassa. | In 1000 parts. | Potassa |
|-------------------------|----------|----------------------|----------|-----------------------------------|---------|
| Pine or fir - - - | 0-45 | Thistles - - - | 5-00 | Bastard chamomile (<i>Anthe-</i> | - |
| Poplar - - - | 0-75 | Flax stems - - - | 5-00 | <i>mis cotula</i> , L.) - - - | 19-6 |
| Trefoil - - - | 0-75 | Small rushes - - - | 8-08 | Sunflower stalks - - - | 20-00 |
| Beechwood - - - | 1-45 | Vine shoots - - - | 8-80 | Common nettle - - - | 25-03 |
| Oak - - - | 1-55 | Barley straw - - - | 8-80 | Vetch plant - - - | 27-50 |
| Boxwood - - - | 2-25 | Dry beech bark - - - | 6-00 | Thistles in full growth - - - | 35-37 |
| Willow - - - | 2-85 | Fern - - - | 6-26 | Dry straw of wheat before | - |
| Elm and maple - - - | 3-90 | Large rush - - - | 7-22 | earling - - - | 47-0 |
| Wheat straw - - - | 3-90 | Stalk of maize - - - | 17-5 | Wormwood - - - | 73-0 |
| Barb of oak twigs - - - | 4-20 | Bean stalks - - - | 20-0 | Fumitory - - - | 79-0 |

Stalks of tobacco, potatoes, chesnuts, chesnut husks, broom, heath, furze, tansy, sorrel, vine leaves, beet leaves, orach, and many other plants, abound in potash salts. In Burgundy, the well-known *cendres gravelées* are made by incinerating the lees of wine pressed into cakes, and dried in the sun; the ashes contain fully 16 per cent. of potassa.

The purification of pearlash is founded upon the fact of its being more soluble in water than the neutral salts which debase it. Upon any given quantity of that substance, in an iron pot, let one and a half times its weight of water be poured, and let a gentle heat be applied for a short time. When the whole has again cooled, the bottom will be encrusted with the salts, while a solution of nearly pure carbonate of potash will be found floating above, which may be drawn off clear by a syphon. The salts may be afterwards thrown upon a filter of gravel. If this lye be diluted with 6 times its bulk of

water mixed with as much slaked lime as there was pearlsh employed, and the mixture be boiled for an hour, the potash will become caustic, by giving up its carbonic acid to the lime. If the clear settled lixivium be now siphoned off, and concentrated by boiling in a covered iron pan, till it assumes the appearance of oil, it will constitute the common caustic of the surgeon, the *potassa fusa* of the shops. But to obtain potassa chemically pure, recourse must be had to the bicarbonate, nitrate, or tartrate of potassa, salts which, when carefully crystallised, are exempt from any thing to render the potassa derived from them impure. The bicarbonate having been gently ignited in a silver basin, is to be dissolved in 6 times its weight of water, and the solution is to be boiled for an hour, along with one pound of slaked lime for every pound of the bicarbonate used. The whole must be left to settle without contact of air. The supernatant lye is to be drawn off by a syphon, and evaporated in an iron or silver vessel provided with a small orifice in its close cover for the escape of the steam, till it assumes, as above, the appearance of oil, or till it be nearly redhot. Let the fused potassa be now poured out upon a bright plate of iron, cut into pieces as soon as it concretes, and put up immediately in a bottle furnished with a well-ground stopper. It is hydrate of potassa, being composed of 1 atom of potassa 48, + 1 atom of water 9 = 57.

A pure carbonate of potassa may be also prepared by fusing pure nitre in an earthen crucible, and projecting charcoal into it by small bits at a time, till it ceases to cause deflagration. Or a mixture of 10 parts of nitre and 1 of charcoal may be deflagrated in small successive portions in a redhot deep crucible. When a mixture of 2 parts of tartrate of potassa, or crystals of tartar, and 1 of nitre, is deflagrated, pure carbonate of potassa remains mixed with charcoal, which by lixiviation, and the agency of quicklime, will afford a pure hydrate. Crystals of tartar calcined alone yield also a pure carbonate.

Caustic potassa, as I have said, after being fused in a silver crucible at a red heat, retains 1 prime equivalent of water. Hence its composition in 100 parts is, potassium 70, oxygen 14, water 16. Anhydrous potassa, or the oxide free from water, can be obtained only by the combustion of potassium in the open air. It is composed of 83½ of metal, and 16½ of oxygen. Berzelius's numbers are, 83·05 and 16·95.

Caustic potassa may be crystallized; but in general it occurs as a white brittle substance of spec. grav. 1·708, which melts at a red heat, evaporates at a white heat, deliquesces into a liquid in the air, and attracts carbonic acid; is soluble in water and alcohol, forms soft soaps with fat oils, and soapy-looking compounds with resins and wax; dissolves sulphur, some metallic sulphurets, as those of antimony, arsenic, &c. as also silica, alumina, and certain other bases; and decomposes animal textures, as hair, wool, silk, horn, skin, &c. It should never be touched with the tongue or the fingers.

The following TABLE exhibits the quantity of *Fused potassa* in 100 parts of *caustic lye*, at the respective densities:—

| Sp. gr. | Pot. in 100. | Sp. gr. | Pot. in 100. | Sp. gr. | Pot. in 100 | Sp. gr. | Pot. in 100. | Sp. gr. | Pot. in 100. |
|---------|--------------|---------|--------------|---------|-------------|---------|--------------|---------|--------------|
| 1·58 | 53·06 | 1·46 | 42·31 | 1·34 | 32·14 | 1·22 | 23·14 | 1·10 | 11·28 |
| 1·56 | 51·58 | 1·44 | 40·17 | 1·32 | 30·74 | 1·20 | 21·25 | 1·08 | 9·20 |
| 1·54 | 50·09 | 1·42 | 37·97 | 1·30 | 29·34 | 1·18 | 19·34 | 1·06 | 7·02 |
| 1·52 | 48·46 | 1·40 | 35·99 | 1·28 | 27·86 | 1·16 | 17·40 | 1·04 | 4·77 |
| 1·50 | 46·45 | 1·39 | 34·74 | 1·26 | 26·34 | 1·14 | 15·98 | 1·02 | 2·44 |
| 1·48 | 44·40 | 1·36 | 33·46 | 1·24 | 24·77 | 1·12 | 13·30 | 1·00 | 0·00 |

The only certain way of determining the quantity of free potassa in any solid or liquid is from the quantity of a dilute acid of known strength which it can saturate.

The hydrate of potassa, or its lye, often contains a notable quantity of carbonate, the presence of which may be detected by lime water, and its amount be ascertained by the loss of weight which it suffers, when a weighed portion of the lye is poured into a weighed portion of dilute sulphuric acid poised in the scale of a balance.

There are two other oxides of potassium; the suboxide, which consists, according to Berzelius, of 90·74 of metal, and 9·26 oxygen; and the hyperoxide, an orange-yellow substance, which gives off oxygen in the act of dissolving in water, and becomes potassa. It consists of 62 of metal, and 38 of oxygen.

Carbonate of potassa is composed of 48 parts of base, and 22 of acid, according to most British authorities; or, in 100 parts, of 68·57 and 31·43; but according to Berzelius, of 68·09 and 31·91.

Carbonate of potassa, as it exists associated with carbon in calcined tartar, passes very readily into the *Bicarbonate*, on being moistened with water, and having a current of carbonic acid gas passed through it. The absorption takes place so rapidly, that the mass

becomes hot, and therefore ought to be surrounded with cold water. The salt should then be dissolved in the smallest quantity of water at 120° Fahr., filtered and crystallized.

Pearl and Pot Ashes imported, in 1850, 184,043 cwts., in 1851, 199,911 cwts.

POTASH, BICHROMATE OF. Mr. Charles Köber obtained in 1840 a patent for the use of bichromate of potash as a substitute for copperas, alum, and other mordants for uniting the colouring ingredients in dyeing with the wool, in consequence of mutual affinity; the ordinary dyeing ingredients being employed in conjunction with the bichromate; he sometimes adds 2 lbs. of argol for 100 lbs. of wool. The chief use of the bichromate seems to be for brightening and fixing the common dyes and mordants.

POTASH AND SODA, CAUSTIC. Mix a solution of 1 part of the dry carbonate salt with 1 part freshly prepared dry hydrate of lime, and allowing it to stand in a closed vessel for 24 hours at a temperature of 68° to 78° Fahr., frequently shaking it. The potash salt should be dissolved in 12 to 15, the soda salt in 7 to 15 parts of water; the carbonate of lime separates in a granulated state, and the clear caustic lye may be decanted. A weaker lye may be obtained from the residue by fresh treatment with water.

POTASH, CHLORATE OF. Chlorate of potash may be economically made by mixing $\frac{5}{4}$ atoms of quicklime with 1 of caustic potash, and passing a current of chlorine gas through the mixture, in a thin pasty state, with water at a boiling heat. Under these conditions, chloride of calcium and chlorate of potash are produced, thus, by the use of lime, the enormous loss of potash, which in the ordinary process is converted into chloride, is avoided; since, instead of producing 43 grs. for 100 grs. of potash, 220 grs. may be obtained, which approaches to the theoretical number 260.

A fact which demonstrates in a remarkable manner how greatly the chemical affinity of chlorine for oxygen is increased by heat, is, that a mere trace of chlorate is produced when chlorine is passed into a mixture of lime and caustic potash at the ordinary temperature.

Another point which results from these experiments is, the influence of the degree of concentration of the liquids. If, for instance, a solution of caustic potash, of 1.040 spec. gr. at 82°, and containing 34 grs. of potash in 1000 grs. of liquid, is mixed with 431 grs. of lime, or 6 equivs., only 131 grs. of chlorate are obtained. Another mixture, made with 1000 grs. of liquid containing 58.75 of potash and 6 equivs. of lime, gave 158 grs. of chlorate of potash. Lastly, by taking a solution of caustic potash of 1.110 sp. gr., and containing 102.33 of potash for 100 grs. of fluid, and adding to it 6 equivs. of caustic lime, heating the whole gradually to 122°, then passing a rapid current of chlorine to saturation (which raises the temperature to about 194°), filtering, evaporating to dryness, redissolving in boiling water, and allowing the whole to cool, 220 grs. of pure chlorate of potash may be obtained. This process has been applied on a large scale, and has perfectly succeeded.

POTASH, PRUSSIAN OF. See PRUSSIAN BLUE.

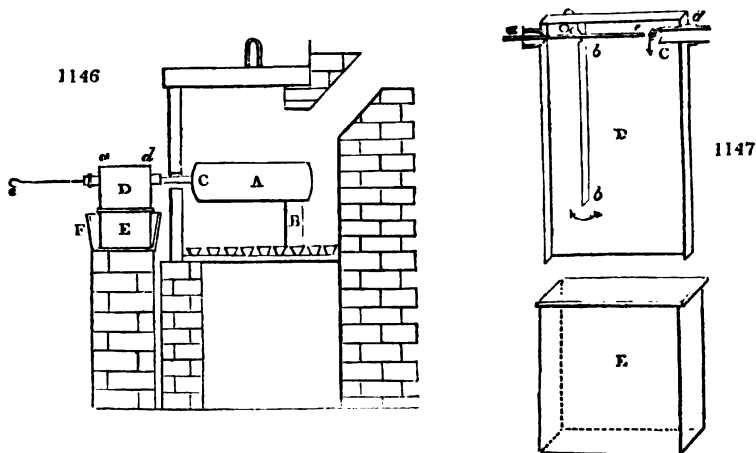
POTASSIUM (Engl. and Fr.; *Kalium*, Germ.); is a metal deeply interesting, not only from its own marvellous properties, but from its having been the first link in the chain of discovery which conducted Sir H. Davy through many of the formerly mysterious and untrodden labyrinths of chemistry.

The easiest and best mode of obtaining this elementary substance is that contrived by Brunner, which I have often practised upon a considerable scale. Into the orifice of one of the iron bottles, as A, *fig.* 889., in which mercury is imported, adapt, by screwing, a piece of gun-barrel tube, 9 inches long; having brazed into its side, about 3 inches from its outer end, a similar piece of iron tube. Fill this retort two-thirds with a mixture of 10 parts of cream of tartar, previously calcined in a covered crucible, and 1 of charcoal, both in powder; and lay it horizontally in an air-furnace, so that while the screw orifice is at the inside wall, the extremity of the straight or nozzle tube may project a few inches beyond the brickwork, and the tube brazed into it at right angles may descend pretty close to the outside wall, so as to dip its lower end a quarter of an inch beneath the surface of some rectified naphtha contained in a copper bottle surrounded by ice-cold water. By bringing the condenser vessel so near the furnace, the tubes along which the potassium vapour requires to pass run less risk of getting obstructed. The horizontal straight end of the nozzle tube should be shut by screwing a stopcock air-tight into it. By opening the cock momentarily, and thrusting in a hot wire, this tube may be readily kept free, without permitting any considerable waste of potassium. The heat should be slowly applied at first, but eventually urged to whiteness, and continued as long as potassurated hydrogen continues to be disengaged. The retort and the part of the nozzle tube exposed to the fire should be covered with a good refractory lute, as described under the article *ΦΥΩΣΦΟΡΑ*. The joints must be perfectly air-tight; and the vessel freed from every trace of mercury, by ignition, before it is charged with the tartar-ash.

Tartar skilfully treated in this way will afford 3 per cent. of potassium; and when

it is observed to send forth green fumes, it has commenced the production of the metal. Instead of the construction above described, the following form of apparatus may be employed.

A, *fig. 1146*, represents the iron bottle, charged with the incinerated tartar; and *a* is a fire-tile support. A piece of fire-tile should also be placed between the bottom of the bottle and the back wall of the furnace, to keep the apparatus steady during the operation. Whenever the moisture is expelled, and the mass faintly ignited, the tube *c* should be screwed into the mouth of the bottle, through a small hole left for



this purpose in the side of the furnace. That tube should be no longer, and the front wall of the furnace no thicker, than what is absolutely necessary. As soon as the reduction is indicated by the emission of green vapours, the receiver must be adapted, *d, a, b, x*, shown in a large scale in *fig 1147*.

This is a condenser, in two pieces, made of thin sheet copper; *d*, the upper part, is a rectangular box, open at bottom, about 10 inches high, by 5 or 6 long and 2 wide; near to the side *a*, it is divided inside into two equal compartments, up to two-thirds of its height, by a partition, *b, b*, in order to make the vapours that issue from *c* pursue a downward and circuitous path. In each of its narrow sides, near the top, a short tube is soldered, at *d* and *a*; the former being fitted air-tight into the end of the nozzle of the retort, while the latter is closed with a cork traversed by a stiff iron probe *e*, which passes through a small hole in the partition *b, b*, under *e*, and is employed to keep the tube *c*, clear, by its drill-shaped steel point. In one of the broad sides of the box, *d*, near the top, a bit of pipe is soldered on at *c*, for receiving the end of a bent glass tube of safety, which dips its other and lower end into a glass containing naphtha. *x*, the bottom copper box, with naphtha, which receives pretty closely the upper case, *d*, is to be immersed in a cistern of cold water, containing some lumps of ice.

The chemical action by which potassa is reduced in this process seems to be somewhat complicated, and has not been thoroughly explained. A very small proportion of pure potassium is obtained; a great deal of it is converted into a black infusible mass, which passes over with the metal, and is very apt to block up the tube. Should this resist clearing out with the probe, the fire must be immediately withdrawn from the furnace, otherwise the apparatus will probably burst or blow up. Care must be taken to prevent any moisture getting into the nozzle, for it would probably produce a violent detonation.

When the operation has proceeded regularly, accompanied to the end with a constant evolution of gas, the retort becomes nearly empty, or contains merely a little charcoal, or carbonate of potassa, and the potassium collects in the naphtha at the bottom of the receiver *x*, in the form of globules or rounded lumps, of greater or less size, and of a leaden hue. But the greater part of the metal escapes with the gas, in a state of combination not well understood. This gaseous compound burns with a white or reddish-white flame, and deposits potassa. Several ounces of potassium may be produced in this way at one operation; but, as thus obtained, it always contains some combined charcoal, which must be separated by distilling it in an iron retort, having its beak plunged in naphtha.

Pure potassium, as procured in Sir H. Davy's original method, by acting upon fused potassa under a film of naphtha, with the negative wire of a powerful voltaic battery, is very like quicksilver. It is semi-fluid at 60° Fahr., nearly liquid at 92°, and entirely so at 120°. At 50° it is malleable, and has the lustre of polished silver; at 32° it is brittle, with a crystalline fracture; and at a heat approaching to redness, it begins to boil, is volatilized, and converted into a green-coloured gas, which condenses into globules upon the surface of a cold body. Its specific gravity in the purest state is 0.865 at 60°. When heated in the air, it takes fire, and burns very vividly. It has a stronger affinity for oxygen than any other known substance; and is hence very difficult to preserve in the metallic state. At a high temperature it reduces almost every oxygenated body. When thrown upon water, it kindles, and moves about violently upon the surface, burning with a red flame, till it be consumed; that is to say, converted into potassa. When thrown upon a cake of ice, it likewise kindles, and burns a hole in it. If a globule of it be laid upon wet turmeric paper, it takes fire, and runs about, marking its desultory parts with red lines. The flame observed in these cases is owing chiefly to hydrogen, for it is at the expense of the water that the potassium burns.

Potassa, even in a pretty dilute solution, produces a precipitate with muriate of platinum, a phenomenon which distinguishes it from soda. It forms, moreover, with sulphuric and acetic acids, salts which crystallize very differently from the sulphates and acetates of soda.

POTASSIUM, CYANURET OF (*Preparation of.*) Introduce into a retort a mixture of two parts of ferro-cyanuret of potash, and 1½ parts of sulphuric acid, previously diluted with 1½ parts of water, and allowed to cool. Place in the receiver a colourless solution of one part of pure hydrate of potash in 3 or 4 parts of alcohol containing 90 per cent. of real alcohol. The receiver or the retort should be tubulated and furnished with a safety tube. The receiver must be cooled as much as possible, and the distillation conducted very slowly, in consequence of the great heat developed in the receiver during the condensation. As soon as the force of ebullition in the retort has subsided, the operation should be stopped, for it is a sign that the greater part of the prussic acid is disengaged; and if the distillation be continued, water will be carried over and mixed with the liquor in the receiver. This liquor is transformed into a thick mixture of precipitated cyanuret of potassium, and the alcoholic solution of the undecomposed potash. The precipitate is to be collected on a filter, freed from the mother water, and washed with alcohol, then pressed and dried on the same filter. Two ounces of ferro-cyanuret of potash, treated in this manner, will produce 6 grammes of cyanuret of potassium. This proportion is a little under the calculation, the reason being that the prussic acid is not entirely disengaged by the distillation, and that the alcohol dissolves about 1 per cent. of its weight of cyanuret of potassium. On the other hand, it is difficult to obtain this combination equally pure by any other method. The alcohol may be regained by distilling it from some metallic salt, such as calcined green vitriol.

POTATO (*Pomme de terre*, Fr.; *Kartofel*, Germ.); is the well-known root of the *Solanum tuberosum*.

Many methods have at different times been tried for preserving potatoes in an unchangeable state, and always ready to be dressed into a wholesome and nutritious dish, but none with such success as the plan of Mr. Downes Edwards, for which he obtained a patent in August, 1840. The potatoes, being first clean washed, are boiled in water or steamed, till their skins begin to crack, then peeled, freed from their specks and eyes, and placed in an iron cylinder, tinned inside, and perforated with many holes one-eighth of an inch in diameter. The potatoes are forced through these by the pressure of a piston. The pulp is finally dried on well-tinned plates of copper, moderately heated by steam, into a granular meal. When this is mixed into a pulp with hot water, and seasoned with milk, &c. it forms a very agreeable food — like fresh mashed potatoes. [See p. 462.]

POTATO SUGAR. Several years ago a sample of sweet mucilaginous liquid was sent to me for analysis by the Hon. the Commissioners of Customs. It was part of a quantity imported in casks at Hull from Rotterdam; it was called by the importers *vegetable juice*. I found it to be imperfectly saccharified starch or fecula; and on my reporting it as such, it was admitted at a moderate rate of duty. Some months after, I received a sample of a similar liquid from the importer at Hull, with a request that I would examine it chemically. He informed me, that an importation just made by him of thirty casks of it had been detained by orders of the Excise till the sugar duty of twenty-five shillings per cwt., of solid matter it contained, was paid upon it. It was of specific gravity 1.362, and contained 80 per cent. of ill-saccharified fecula.

In the interval between the first importation and the second, an Act of Parliament had been obtained for placing every kind of sugar, from whatever material it was formed, under the provisions of the beet root sugar bill. As the saccharometer tables, subservient to the levying of the Excise duties under this Act, were constructed by me at

The following TABLE exhibits several good analyses of the potato:—

| Sort. | Fibrine. | Starch. | Veg. album. | Gum. | Acids and Salts. | Water. | Analyst. |
|--|----------|---------|-------------|------|------------------|--------|----------|
| Red potatoes - | 7·0 | 15·0 | 1·4 | 4·1 | 5·1 | 75·0 | Einhof. |
| Id. germinated - | 6·8 | 15·2 | 1·3 | 3·7 | — | 73·0 | — |
| Potato sprouts - | 2·8 | 0·4 | 0·4 | 3·3 | — | 93·0 | — |
| Kidney potatoes - | 8·8 | 9·1 | 0·8 | — | — | 81·3 | — |
| Large red do. - | 6·0 | 12·9 | 0·7 | — | — | 78·0 | — |
| Sweet do. - | 8·2 | 15·1 | 0·8 | — | — | 74·3 | — |
| Potato of Peru - | 5·2 | 15·0 | 1·9 | 1·9 | | 76·0 | Lampad. |
| .. England - | 6·8 | 12·9 | 1·1 | 1·7 | | 77·5 | — |
| Onion potato - | 8·4 | 18·7 | 0·9 | 1·7 | | 70·3 | — |
| .. Voigtland - | 7·1 | 15·4 | 1·2 | 2·0 | | 74·3 | — |
| .. cultivated in the environs of Paris | 6·79 | 13·3 | 0·92 | 3·3 | 1·4 | 73·12 | Henry. |

the request of the president of the board, I was aware that fifty per cent. of the syrup of the beet root was deducted as a waste product, because beet root molasses are too crude an article for the use of man. Well saccharified starch paste, however, constitutes a syrup, poor indeed in sweetness when compared with cane syrup or that of the beet root; but then it does not spontaneously blacken into molasses by evaporation, as solutions of ordinary sugar never fail to do when they are concentrated even with great care. Hence the residuary syrups of saccharified fecula may be all worked up into a tolerably white concrete mass, which, being pulverized, is used by greedy grocers to mix with their dark brown bastard sugars to improve their colour.

It is not many years that sugar has been in this country manufactured from potato starch to any extent, though it has been long an object of commercial enterprise in France, Belgium, and Holland, where the large coarse potatoes are used for this purpose. The raw material must be very cheap, as well as the labour, for potato flour or starch, for conversion into sugar, has been imported from the continent into this country in large quantities, and sold in London at the low price of sixteen shillings per cwt.

The process usually followed by the potato sugar makers is to mix 100 gallons of boiling water with every 112 lbs. of the fecula, and 2 lbs. of the strongest sulphuric acid. This mixture is boiled about 12 hours in a large vat, made of white deal, having lead pipes laid along its bottom, which are connected with a high-pressure steam boiler. After being thus saccharified, the acid liquid is neutralized with chalk, filtered, and then evaporated to the density of about 1·300, at the boiling temperature, or exactly 1·342, when cooled to 60°. When syrup of this density is left in repose for some days, it concretes altogether into crystalline tufts, and forms an apparently dry solid, of specific gravity 1·39. When this is exposed to the heat of 220° it fuses into a liquid nearly as thin as water; on cooling to 150° it takes the consistence of honey, and at 100° Fahr. it has that of viscid varnish. It must be left a considerable time at rest before it recovers its pristine state. When heated to 270° it boils briskly, gives off one-tenth of its weight of water, and concretes on cooling into a bright yellow, brittle, but deliquescent mass, like barley sugar. If the syrup be concentrated to a much greater density than 1·340, as to 1·362, or if it be left faintly acidulous, in either case it will not granulate, but will remain either a viscid magma, or become a concrete mass, which may indeed be pulverized, though it is so deliquescent as to be unfit for the adulteration of raw sugar.

The Hull juice is in this predicament, and is therefore, in my opinion, hardly amenable to the new sugar law, as it cannot by any means be worked up into even the resemblance of sugar. Good muscovado sugar from Jamaica fuses only when heated to 280°, but it turns immediately dark-brown from the disengagement of some of its carbon at that temperature, and becomes, in fact, the substance called *caramel* by the French, which is used for colouring brandies, white wines, and liqueurs. Thus starch or grape sugar is well distinguished from cane sugar, by its fusibility at a moderate heat, and its unalterability at a pretty high heat. Its sweetening power is only two-fifths of that of ordinary sugar. A good criterion of incompletely formed grape sugar is its resisting the action of sulphuric acid, while perfectly saccharified starch or cane sugar is readily decomposed by it. If to a strong solution of imperfectly saccharified grape sugar, nearly boiling hot, one drop of sulphuric acid be let fall, no perceptible change will ensue; but if the acid be dropped into solutions of either of the other two sugars, black carbonaceous particles will make their appearance. The article which was lately detained by the Excise for the high duties at Hull is not affected by sulphuric

acid, as are solutions of cane sugar, and of the well made potato sugar of London; and for this reason I gave my opinion in favour of admitting the so-called vegetable juice at a moderate rate of duty.

I subjected the solid matter, obtained by evaporating the Hull juice, to ultimate analysis, by peroxide of copper, in a combustion tube, with all the requisite precautions; and obtained in one experiment 37 per cent. of carbon, and in another 33 per cent., when the substance had been dried in an air-bath heated to 275°. The difference to 100 is hydrogen and oxygen in the proportion to form water. Now, this is the constitution of grape sugar. Cane sugar contains about 5 per cent. more carbon, whereby it readily evolves this black element by the action of heat or sulphuric acid.

An ingenious memoir, by Mr. Trommer, upon the distinguishing criteria of gum, dextrine, grape sugar, and cane sugar, has been published in the 3rd volume of the *Annalen der Chemie und Pharmacie*. I have repeated his experiments, and find them to give correct results, when modified in a certain way. His general plan is to expose the hydrate of copper to the action of solutions of the above mentioned vegetable products. He first renders the solution alkaline, then adds solution of sulphate of copper to it, and either heats the mixture, or leaves it for some time in the cold. By pursuing his directions, I encountered contradictory results; but by the following method, I have secured uniform success in applying the criteria, and have even arrived at a method of determining, by a direct test, the quantity of sugar in diabetic urine.

I dissolve a weighed portion of sulphate of copper in a measured quantity of water, and make the solution faintly alkaline, as tested with turmeric paper, not litmus, by the addition of potash lye in the cold, for if the mixture be hot, a portion of the disengaged green hydrate of copper is converted into black oxide. This mixture being always agitated before applying it, forms the test liquor. If a few drops of it be introduced into a solution of gum, no change ensues on the hydrate of copper, even at a boiling heat, which shows that a gummate of copper is formed which resists decomposition; but the cupreous mixture, without the gum, is rapidly blackened at a boiling temperature. I do not find that the gummate is redissolved by an excess of water, as Trommer affirms. Starch and tragacanth comport like gum, in which respect I agree with Trommer; starch, however, possesses already a perfect criterion in iodine water. Mr. Trommer says, that solution of dextrine affords a deep blue coloured liquid, without a trace of precipitate; and that when his mixture is heated to 85° C. it deposits red grains of protoxide of copper, soluble in muriatic acid. I think these phenomena are dependent, in some measure, upon the degree of alkaline excess in the mixture. I find that lution of dextrine treated in my way hardly changes in the cold, but when heated slightly becomes green, and by brisk boiling an olive tint is produced; it thus betrays its tendency of transition into sugar. Solution of cane sugar, similarly treated, undergoes no change in the cold at the end of two days; and even very little change of colour, even at a boiling heat, if not too concentrated. Cane sugar, treated by Trommer in his way, becomes of a deep blue; it can be boiled with potash in excess without any separation of orange red oxide of copper.

Starch, or grape sugar, has a marvellous power of reducing the green hydrate of copper to the orange oxide, but I find it will not act upon the pure blue hydrate even when recently precipitated; it needs the addition in this case also of a small portion of alkali; but ammonia does not seem to serve the purpose, for on using the ammonia-sulphate of copper in solution, I obtained unsatisfactory results with the above vegetable products. The black oxide of copper is not affected by being boiled in a solution of starch sugar. "If solution of grape sugar," says Trommer, "and potash be treated with a solution of sulphate of copper, till the separated hydrate is re-dissolved, a precipitate of red oxide will soon take place at common temperature; but it immediately forms, if the mixture is heated. A liquid containing $\frac{10}{100000}$ of grape sugar, even $\frac{1}{1000000}$ part," says he, "gives a perceptible tinge (orange) if the light is let fall upon it." To obtain such a minute result, very great nicety must be used in the dose of alkali, which I have found it extremely difficult to hit. With my regulated alkaline mixture, however, I never fail in detecting an exceedingly small portion of starch sugar, even when mixed with Muscovado sugar; and thus an excellent method is afforded of detecting the frauds of the grocers.

I find that manna deoxidizes the green hydrate of copper slowly when heated, but not nearly to the same extent as grape sugar, which reduces it rapidly to the orange oxide.

If an excess of the hydrate of copper test be used, there will be a deposit of green hydrate at the bottom of the vessel.

To apply these researches to the sugar of diabetic urine. This should first be boiled briskly to decompose the urea and to dissipate its elements in the form of ammonia, as well as to concentrate the saccharine matter, whereby the test becomes more efficacious. Then add to the boiling urine, in a few drops at a time, a cupreous mixture containing

a known quantity of the sulphate of copper, till the mixture assumes a greenish tint, and continue the heat till the colour becomes bright orange. Should it remain green it is a proof that more hydrate of copper has been introduced than is equivalent to the deoxidizing power of the starch sugar. I have found that one grain of sulphate of copper in solution, supersaturated very slightly with potash, is decomposed with the production of orange protoxide by about three grains of potato sugar; or more exactly thirty parts of the said sulphate, in the state of an alkaline hydrate of copper, pass altogether into the state of orange oxide, by means of 100 parts of granular starch sugar. Thus, for every three grains of sulphate so changed, ten grains of sugar may be estimated to exist in diabetic urine.

Acetate of copper may be used in the above experiments, but it is not so good as the sulphate. The chloride of copper does not answer.

Specific gravity is also an important criterion applied to sugar; that of the cane and beet root is 1.577, not 1.6065 as given by Berzelius and others; that of starch sugar, in crystalline tufts, is 1.39, or perhaps 1.40, as it varies a little with its state of dryness. At 1.342, syrup of the cane contains seventy per cent. of sugar; at the same density syrup of starch sugar contains seventy-five and a half per cent. of concrete matter, dried at 260° (Fahr.), and, therefore, freed from the ten per cent. of water, which it contains in the granular state. Thus, another distinction is obtained between the two sugars in the relative densities of their solutions, at like saccharine contents, per cent.

POTTERY, PORCELAIN (Eng. and Fr.; *Steingut, Porzellan*, Germ.) The French call this art *céramique*, from the Greek noun *κεραμος*, an earthen pot, or *burned clay*. In reference to chemical constitution, there are only two genera of baked stoneware. The first consists of a fusible earthy mixture, along with an infusible, which when combined are susceptible of becoming semi-vitrified and translucent in the kiln. This constitutes porcelain or china-ware; which is either hard and genuine, or tender and spurious, according to the quality and quantity of the fusible ingredient. The second kind consists of an infusible mixture of earths, which is refractory in the kiln, and continues opaque. This is pottery, properly so called; but it comprehends several sub-species, which graduate into each other by imperceptible shades of difference. To this head belong earthenware, stoneware, flint-ware, *fayence*, delftware, iron-stone china, &c.

The earliest attempts to make a compact stoneware, with a painted glaze, seem to have originated with the Arabians in Spain, about the 9th century, and to have passed thence into Majorca, in which island they were carried on with no little success. In the 14th century, these articles, and the art of imitating them, were highly prized by the Italians, under the name of *Majolica*, and *porcelana*, from the Portuguese word for a cup. The first fabric of stoneware possessed by them was erected at *Fayenza*, in the ecclesiastical state, whence the French term *fayence* is derived. The body of the ware was usually a red clay, and the glaze was opaque, being formed of the oxides of lead and tin, along with potash and sand. Bernhard de Pallissy, about the middle of the 16th century, manufactured the first white *fayence*, at *Saintes*, in France; and not long afterwards the Dutch produced a similar article, of substantial make, under the name of *delftware*, and *delft porcelain*, but destitute of those graceful forms and paintings for which the ware of *Fayenza* was distinguished. Common *fayence* may be, therefore, regarded as a strong, well-burned, but rather coarse-grained kind of stoneware.

It was in the 17th century that a small work for making earthenware of a coarse description, coated with a common lead glaze, was formed at *Burslem*, in *Staffordshire*, which may be considered as the germ of the vast potteries now established in that county. The manufacture was improved about the year 1690, by two Dutchmen, the brothers *Elers*, who introduced the mode of glazing ware by the vapour of salt, which they threw by handfuls at a certain period among the ignited goods in the kiln. But these were rude, unscientific, and desultory efforts. It is to the late *Josiah Wedgwood, Esq.*, that this country and the world at large are mainly indebted for the great modern advancement of the *ceramic* art. It was he who first erected magnificent factories, where every resource of mechanical and chemical science was made to co-operate with the arts of painting, sculpture, and statuary, in perfecting this valuable department of the industry of nations. So sound were his principles, so judicious his plans of procedure, and so ably have they been prosecuted by his successors in *Staffordshire*, that a population of upwards of 100,000 operatives now derives a comfortable subsistence within a district formerly bleak and barren, of 8 miles long, by 6 broad, which contains 250 kilns, and is significantly called the *Potteries*.

OF THE MATERIALS OF POTTERY OR PORCELAIN, AND THEIR PREPARATION.

1. *Clay*.—The best clay from which the *Staffordshire* ware is made, comes from *Dorsetshire*; and a second quality from *Devonshire*: but both are well adapted for working, being refractory in the fire, and becoming very white when burnt. The clay is cleaned as much as possible by hand, and freed from loosely adhering stones at the

pits where it is dug. In the factory mounted by Mr. Wedgwood, which may be regarded as a type of excellence, the clay is cut to pieces, and then kneaded into a pulp with water, by engines; instead of being broken down with pickaxes, and worked with water by hand-paddles, in a square pit or water-tank, an old process, called *blannging*. The clay is now thrown into a cast-iron cylinder, 20 inches wide, and 4 feet high, or into a cone 2 feet wide at top, and 6 feet deep, in whose axis an upright shaft revolves, bearing knives as radii to the shaft. The knives are so arranged, that their flat sides lie in the plane of a spiral line; so that by the revolution of the shaft, they not only cut through every thing in their way, but constantly press the soft contents of the cylinder or cone obliquely downwards, on the principle of a screw. Another set of knives stands out motionless at right angles from the inner surface of the cylinder, and projects nearly to the central shaft, having their edges looking opposite to the line of motion of the revolving blades. Thus the two sets of slicing implements, the one active, and the other passive, operate like shears in cutting the clay into small pieces, while the active blades, by their spiral form, force the clay in its comminuted state out at an aperture at the bottom of the cylinder or cone, whence it is conveyed into a cylindrical vat, to be worked into a pap with water. This cylinder is tub-shaped, being about 4 times wider than it is deep. A perpendicular shaft turns also in the axis of this vat, bearing cross spokes one below another, of which the vertical set on each side is connected by upright staves, giving the movable arms the appearance of two or four opposite square paddle-boards revolving with the shaft. This wooden framework, or large blunger, as it is called, turns round amidst the water and clay lumps, so as to beat them into a fine pap, from which the stony and coarse sandy particles separate, and subside to the bottom. Whenever the pap has acquired a cream-consistenced uniformity, it is run off through a series of wire, lawn, and silk sieves, of different degrees of fineness, which are kept in continual agitation backwards and forward by a crank mechanism; and thus all the grosser parts are completely separated, and hindered from entering into the composition of the ware. This clay liquor is set aside in proper cisterns, and diluted with water to a standard density.

2. But clay alone cannot form a proper material for stoneware, on account of its great contractibility by heat, and the consequent cracking and splitting in the kiln of the vessels made of it; for which reason, a siliceous substance incapable of contraction must enter into the body of pottery. For this purpose, ground flints, called flint-powder by the potters, is universally preferred. The nodules of flint extracted from the chalk formation, are washed, heated red-hot in a kiln, like that for burning lime, and thrown in this state into water, by which treatment they lose their translucency, and become exceeding brittle. They are then reduced to a coarse powder in a stamping-mill, similar to that for stamping ores; see METALLURGY. The pieces of flint are laid on a strong grating, and pass through its meshes whenever they are reduced by the stamps to a certain state of comminution. This granular matter is now transferred to the proper flint-mill, which consists of a strong cylindrical wooden tub, bottomed with flat pieces of massive *chert*, or hornstone, over which are laid large flat blocks of similar chert, that are moved round over the others by strong iron or wooden arms projecting from an upright shaft made to revolve in the axis of the mill-tub. Sometimes the active blocks are fixed to these cross arms, and thus carried round over the passive blocks at the bottom. See *infra*, under PORCELAIN, figures of the flint and felspar mill. Into this cylindrical vessel a small stream of water constantly trickles, which facilitates the grinding motion and action of the stones, and works the flint powder and water into a species of pap. Near the surface of the water there is a plug-hole in the side of the tub, by which the creamy-looking flint liquor is run off from time to time, to be passed through lawn or silk sieves, similar to those used for the clay liquor; while the particles that remain on the sieves are returned into the mill. This pap is also reduced to a standard density by dilution with water; whence the weight of dry siliceous earth present, may be deduced from the measure of the liquor.

The standard clay and flint liquors are now mixed together, in such proportion by measure, that the flint powder may bear to the dry clay the ratio of one to five, or occasionally one to six, according to the richness or plasticity of the clay; and the liquors are intimately incorporated in a revolving churn, similar to that employed for making the clay-pap. This mixture is next freed from its excess of water, by evaporation in oblong stone troughs, called *slip-kilns*, bottomed with fire-tiles, under which a furnace flue runs. The breadth of this evaporating trough varies from 2 to 6 feet; its length from 20 to 50; and its depth from 8 to 12 inches, or more.

By the dissipation of the water, and careful agitation of the pap, an uniform doughy mass is obtained; which, being taken out of the trough, is cut into cubical lumps. These are piled in heaps, and left in a damp cellar for a considerable time; that is, several months, in large manufactories. Here the dough suffers disintegration, promoted by a kind of fermentative action, due probably to some vegetable matter in the water

and the clay; for it becomes black, and exhales a fetid odour. The argillaceous and siliceous particles get disintegrated also by the action of the water, in such a way that the ware made with old paste is found to be more homogeneous, finer grained, and not so apt to crack or to get disfigured in the baking, as the ware made with newer paste.

But this chemical comminution must be aided by mechanical operations; the first of which is called the potter's *slapping* or *wedging*. It consists in seizing a mass of clay in the hands, and, with a twist of both at once, tearing it into two pieces, or cutting it with a wire. These are again slapped together with force, but in a different direction from that in which they adhered before, and then dashed down on a board. The mass is once more torn or cut asunder at right angles, again slapped together, and so worked repeatedly for 20 or 30 times, which ensures so complete an incorporation of the different parts, that if the mass had been at first half black and half white clay, it would now be of a uniform gray colour. A similar effect is produced in some large establishments by a slicing machine, like that used for cutting down the clay lumps as they come from the pit.

In the axis of a cast iron cylinder or cone, an upright shaft is made to revolve, from which the spiral-shaped blades extend, with their edges placed in the direction of rotation. The pieces of clay subjected to the action of these knives (with the reaction of fixed ones) are minced to small morsels, which are forced pell-mell by the screw-like pressure into an opening of the bottom of the cylinder or cone, from which a horizontal pipe about 6 inches square proceeds. The dough is made to issue through this outlet, and is then cut into lengths of about 12 inches. These clay pillars or prisms are thrown back into the cylinder, and subjected to the same operation again and again, till the lumps have their particles perfectly blended together. This process may advantageously precede their being set aside to ripen in a damp cellar. In France the stoneware dough is not worked in such a machine; but after being beat with wooden mallets, a practice common also in England, it is laid down on a clean floor, and a workman is set to tread upon it with naked feet for a considerable time, walking in a spiral direction from the centre to the circumference, and from the circumference to the centre. In Sweden, and also in China (to judge from the Chinese paintings which represent their manner of making porcelain), the clay is trodden to a uniform mass by oxen. It is afterwards, in all cases, kneaded like baker's dough, by folding back the cake upon itself, and kneading it out, alternately.

The process of *slapping* consists in cutting through a large mass with a wire, lifting up either half in both hands, and casting it down with great violence on the other; and this violent treatment of the clay is repeated till every appearance of air-bubbles is removed, for the smallest remaining vesicle expanding in the kiln, would be apt to cause blisters or warts upon the ware.

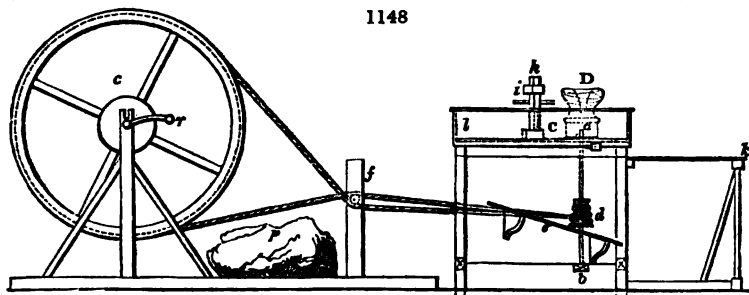
Having thus detailed the preparation of the stoneware paste, we have next to describe the methods of forming it into articles of various forms.

Throwing is performed upon a tool called the potter's lathe. (See fig., *infra*.) This consists of an upright iron shaft, about the height of a common table, on the top of which is fixed, by its centre, a horizontal disc or circular piece of wood, of an area sufficiently great for the largest stoneware vessel to stand upon. The lower end of the shaft is pointed, and runs in a conical step, and its collar, a little below the top-board, being truly turned, is embraced in a socket attached to the wooden frame of the lathe. The shaft has a pulley fixed upon it, with grooves for 3 speeds, over which an endless band passes from a fly-wheel, by whose revolution any desired rapidity of rotation may be given to the shaft and its top-board. This wheel, when small, may be placed alongside, as in the turner's lathe, and then it is driven by a treadle and crank; or when of larger dimensions, it is turned by the arms of a labourer. Sometimes, indeed, the wooden plate is replaced by a large thick disc of Paris plaster, which is whirled round by the hand of the potter, without the intervention of a pulley and fly-wheel, and affords sufficient centrifugal power for fashioning small vessels. The mass of dough to be thrown, is weighed out or gauged by an experienced hand. The thrower dashes down the lump on the centre of the revolving board, and dipping his hands frequently in an adjoining tub of water, he works up the clay into a tall irregular cylinder, and then down into a cake, alternately, till he has secured the final extrication of air-bubbles, and then gives the proper form to the vessel under a less speed of rotation, regulating its dimensions by wooden pegs and gauges. He now cuts it off at the base with a piece of fine brass wire, fastened to a handle at either end. The vessel thus rudely fashioned is placed in a situation where it may dry gradually to a proper point. At a certain stage of the drying, called the *green state*, it possesses a greater tenacity than at any other, till it is baked. It is then taken to another lathe, called the turning lathe, where it is attached by a little moisture to the vertical face of a wooden chuck, and turned nicely into its proper shape with a very sharp tool, which also smooths it. After this it is slightly burnished with a smooth steel surface.

DESCRIPTION OF THE POTTER'S LATHE.

A, *fig. 1148*, is the profile of the English potter's lathe, for blocking out round ware; *c* is the table or tray; *a* is the head of the lathe, with its horizontal disc; *a, b*, is the upright shaft of the head; *d*, pulleys with several grooves of different diameters, fixed upon the shaft, for receiving the driving-cord or band; *k* is a bench upon which the workman sits astride; *e*, the treadle foot-board; *l* is a ledge-board,

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for catching the shavings of clay which fly off from the lathe; *k* is an instrument, with a slide-nut *i*, for measuring the objects in the blocking out; *e* is the fly-wheel with its winch-handle *r*, turned by an assistant; the sole-frame is secured in its place by the heavy stone *p*; *f* is the oblong guide-pulley, having also several grooves for converting the vertical movement of the fly-wheel into the horizontal movement of the head of the lathe.

b is one of the intermediate forms given by the potter to the ball of clay, as it revolves upon the head of the lathe.

In large potteries, the whole of the lathes, both for throwing and turning, are put in motion by a steam-engine. The vertical spindle of the lathe has a bevel wheel on it, which works in another bevel toothed wheel fixed to a horizontal shaft. This shaft is provided with a long conical wooden drum, from which a strap ascends to a similar conical drum on the main lying shaft. The apex of the one cone corresponds to the base of the other, which allows the strap to retain the same degree of tension (see the conical drum apparatus of the *Stearine-press*), while it is made to traverse horizontally, in order to vary the speed of the lathe at pleasure. When the belt is at the base of the driving-cone, it works near the vortex of the driven one, so as to give a maximum velocity to the lathe, and *vice versa*.

During the throwing of any article, a separate mechanism is conducted by a boy, which makes the strap move parallel to itself along these conical drums, and nicely regulates the speed of the lathe. When the strap runs at the middle of the cones, the velocity of each shaft is equal. By this elegant contrivance of parallel cones reversed, the velocity rises gradually to its maximum, and returns to its minimum or slower motion when the workman is about finishing the article thrown. The strap is then transferred to a pair of loose pulleys, and the lathe stops. The vessel is now cut off at the base with a small wire; is dried, turned on a power lathe, and polished as above described.

The same degree of dryness which admits of the clay being turned on the lathe, also suits for fixing on the handles and other appendages to the vessels. The parts to be attached being previously prepared, are joined to the circular work by means of a thin paste which the workmen call *slip*, and the seams are then smoothed off with a wet sponge. They are now taken to a stove-room heated to 80° or 90° F., and fitted up with a great many shelves. When they are fully dried, they are smoothed over with a small bundle of hemp, if the articles be fine, and are then ready for the kiln, which is to convert the tender clay into the hard *biscuit*.

A great variety of pottery wares, however, cannot be fashioned on the lathe, as they are not of a circular form. These are made by two different methods, the one called *press-work*, and the other *casting*. The *press-work* is done in moulds made of Paris plaster, the one half of the pattern being formed in the one side of the mould, and the other half in the other side: these moulding-pieces fit accurately together. All vessels of an oval form, and such as have flat sides, are made in this way. Handles of teapots, and fluted solid rods of various shapes, are formed by pressure also; viz., by squeezing the dough contained in a pump-barrel through different shaped orifices at its bottom, by working a screw applied to the piston-rod. The worm-shaped dough, as it issues, is cut to proper lengths, and bent into the desired form. Tubes may be also made on the same pressure principle, only a tubular opening must be provided in the bottom plate of the clay-forcing pump.

The other method of fashioning earthenware articles is called *casting*, and is, perhaps, the most elegant for such as have an irregular shape. This operation consists in pouring the clay, in the state of pap or slip, into plaster moulds, which are kept in a deaicated state. These moulds, as well as the pressure ones, are made in halves, which nicely correspond together. The slip is poured in till the cavity is quite full, and is left in the mould for a certain time, more or less, according to the intended thickness of the vessel. The absorbent power of the plaster soon abstracts the water, and makes the coat of clay in contact with it quite doughy and stiff, so that the part still liquid being poured out, a hollow shape remains, which when removed from the mould constitutes the half of the vessel, bearing externally the exact impress of the mould. The thickness of the clay varies with the time that the paste has stood upon the plaster. These cast articles are dried to the green state, like the preceding, and then joined accurately with *slip*. Imitations of flowers and foliage are elegantly executed in this way. This operation, which is called *furnishing*, requires very delicate and dexterous manipulation.

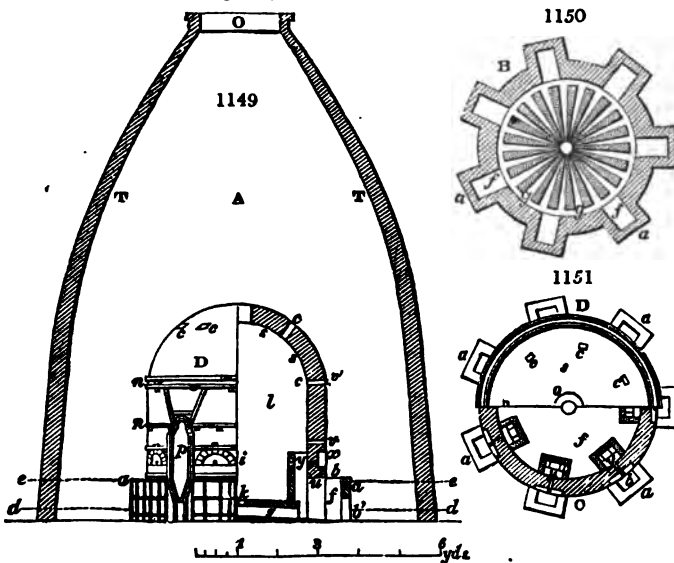
The saggars for the unglazed coloured stoneware should be covered inside with a glaze composed of 12 parts of common salt and 30 of potash, or 6 parts of potash and 14 of salt; which may be mixed with a little of the common enamel for the glazed pottery saggars. The bottom of each sagger has some bits of flints sprinkled upon it, which become so adherent after the first firing as to form a multitude of little prominences for setting the ware upon, when this does not consist of plates. It is the duty of the workmen belonging to the glaze kiln to make the saggars during the intervals of their work; or if there be a relay of hands, the man who is not firing makes the saggars.

The English kilns differ from those of France and Germany, in their construction, in the nature of their fuel, and in the high temperature required to produce a surface sufficiently hard for a perfectly fine glaze.

When the ware is sufficiently dry, and in sufficient quantity to fill a kiln, the next process is placing the various articles in the baked fire-clay vessels, which may be either of a cylindrical or oval shape; called *gazettes*, Fr.; *kapseln*, Germ. These are from 6 to 8 inches deep, and from 12 to 18 inches in diameter. When packed full of the dry ware, they are piled over each other in the kiln. The bottom of the upper sagger forms the lid of its fellow below; and the junction of the two is luted with a ring of soft clay applied between them. These dishes protect the ware from being suddenly and unequally heated, and from being soiled by the smoke and vapours of the fuel. Each pile of saggars is called a *bang*.

POTTERY KILN OF STAFFORDSHIRE.

Figs. 1149, 50, 51, 52, 53, represent the kiln for baking the biscuit, and also for running the glaze, in the English potteries.

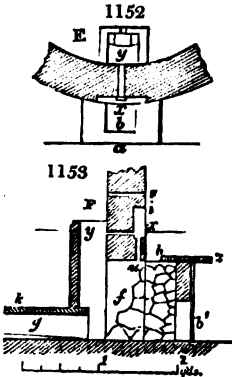


a, a, *Figs.* 1149, 1150, 1151. are the furnaces which heat the kiln; of which *b*, in *fig.* 1149., are the upper mouths, and *b'* the lower; the former being closed more or less by the fire-tile *x*, shown in *fig.* 1153.

f is one fireplace; for the manner of distributing the fuel in it, see *fig.* 1153.

g, y, *Figs.* 1149. & 1153., are the horizontal and vertical flues and chimneys for conducting the flame and smoke. *l* is the laboratory, or body of the kiln; having its floor *k* sloping slightly downwards from the centre to the circumference. *x, y*, is the slit of the horizontal register, leading to the chimney flue *y* of the furnace, being the first regulator; *x, w*, is the vertical register conduit, leading to the furnace or mouth *f*, being the second regulator; *v* is the register slit above the furnace, and its vertical flue leading into the body of the kiln; *v', c*, slit for regulating flue at the shoulder of the kiln; *i* is an arch which supports the walls of the kiln, when the furnace is under repair; *c, c*, are small flues in the vault *s* of the laboratory. *h*, *Fig.* 1150., is the central flue, called *lunette*, of the laboratory.

z, z, is the conical tower or *howell*, strengthened with a series of iron hoops. *o* is the great chimney or *lunette* of the tower; *p* is the door of the laboratory, bound inside with an iron frame.



A, is the complete kiln and *howell*, with all its appurtenances.

B, *fig.* 1150., is the plan at the level *d, d*, of the floor, to show the arrangement and distribution of all the horizontal flues, both circular and radiating.

C, *fig.* 1151., is a plan at the level *e, e*, of the upper mouths *b*, of the furnaces, to show the disposition of the fireplaces of the vertical flues, and of the horizontal registers, or peep-holes.

D, *fig.* 1151., is a bird's-eye view of the top of the vault or dome *s*, to show the disposition of the vent-holes *c, c*.

E, *fig.* 1152., is a detailed plan at the level *c, c*, of one furnace and its dependencies.

F, *fig.* 1153., is a transverse section, in detail, of one furnace and its dependencies.

The same letters in all the figures indicate the same objects.

Charging of the kiln.—The saggars are piled up first in the space between each of the upright furnaces, till they rise to the top of the flues. These contain the smaller articles. Above

this level, large fire tiles are laid, for supporting other saggars, filled with teacups, sugar-basins, &c. In the bottom part of the pile, within the preceding, the same sorts of articles are put; but in the upper part all such articles are placed as require a high heat. Four piles of small saggars, with a middle one 10 inches in height, complete the charge. As there are 6 piles between each furnace, and as the biscuit kiln has 8 furnaces, a charge consequently amounts to 48 or 50 *bungs*, each composed of from 18 to 19 saggars. The inclination of the bungs ought always to follow the form of the kiln, and should therefore tend towards the centre, lest the strong draught of the furnaces should make the saggars fall against the walls of the kiln, an accident apt to happen were these piles perpendicular. The last sagger of each bung is covered with an unbaked one, three inches deep, in place of a round lid. The watches are small cups, of the same biscuit as the charge, placed in saggars, four in number, above the level of the flue-tops. They are taken hastily out of the saggars, lest they should get smoked, and are thrown into cold water.

When the charging is completed, the firing is commenced, with coal of the best quality. The management of the furnaces is a matter of great consequence to the success of the process. No greater heat should be employed for some time than may be necessary to agglutinate the particles which enter into the composition of the paste, by evaporating all the humidity; and the heat should never be raised so high as to endanger the fusion of the ware, which would make it very brittle.

When ever the mouth or door of the kiln is built up, a child prepares several fires in the neighbourhood of the *howell*, while a labourer transports in a wheelbarrow a supply of coals, and introduces into each furnace a number of lumps. These lumps divide the furnace into two parts; those for the upper flues being placed above, and those for the ground flues below, which must be kept unobstructed.

The fire-mouths being charged, they are kindled to begin the baking, the regulator tile *x*, *fig.* 1153., being now opened; an hour afterwards the bricks at the bottom of the furnace are stopped up. The fire is usually kindled at 6 o'clock in the evening, and progressively increased till 10, when it begins to gain force, and the flame rises half-way up the chimney. The second charge is put in at 8 o'clock, and the mouths of the furnaces are then covered with tiles; by which time the flame issues through the vent of the tower. An hour afterwards a fresh charge is made; the tiles *x*, which cover the furnaces, are slipped

back ; the cinders are drawn to the front, and replaced with small coal. About half-past 11 o'clock the kiln-man examines his furnaces, to see that their draught is properly regulated. An hour afterwards a new charge of coal is applied ; a practice repeated hourly till 6 o'clock in the morning. At this moment he takes out his first *watch*, to see how the baking goes on. It should be at a very pale-red heat ; but the watch of 7 o'clock should be a deeper red. He removes the tiles from those furnaces which appear to have been burning too strongly, or whose flame issues by the orifices made in the shoulder of the kiln ; and puts tiles upon those which are not hot enough. The flames glide along briskly in a regular manner. At this period he draws out the watches every quarter of an hour, and compares them with those reserved from a previous standard kiln ; and if he observes a similarity of appearance, he allows the furnaces to burn a little longer ; then opens the mouths carefully and by slow degrees ; so as to lower the heat, and finish the round.

The baking usually lasts from 40 to 42 hours ; in which time the biscuit kiln may consume 14 tons of coals ; of which four are put in the first day, seven the next day and following night, and the four last give the strong finishing heat.

Emptying the kilns. — The kiln is allowed to cool very slowly. On taking the ware out of the saggars, the biscuit is not subjected to friction, as in the foreign potteries, because it is smooth enough ; but is immediately transported to the place where it is to be dipped in the glaze or enamel tub. A child makes the pieces ring, by striking with the handle of the brush, as he dusts them, and then immerses them into the glaze cream ; from which tub they are taken out by the enameller, and shaken in the air. The tub usually contains no more than 4 or 5 inches depth of the glaze, to enable the workman to pick out the articles more readily, and to lay them upon a board, whence they are taken by a child to the glaze kiln.

Glazing. — A good enamel is an essential element of fine stoneware ; it should experience the same dilatation and contraction by heat and cold as the biscuit which it covers. The English enamels contain nothing prejudicial to health, as many of the foreign glazes do ; no more lead being added to the former than is absolutely necessary to convert the siliceous and aluminous matters with which it is mixed into a perfectly neutral glass.

Three kinds of glazes are used in Staffordshire ; one for the common pipe-clay or cream-coloured ware ; another for the finer pipe-clay ware to receive impressions, called *printing body* ; a third for the ware which is to be ornamented by painting with the pencil.

The glaze of the first or common ware is composed of 53 parts of white lead, 16 of Cornish stone, 36 of ground flints, and 4 of flint glass ; or of 40 of white lead, 36 of Cornish stone, 12 of flints, and 4 of flint or crystal glass. These compositions are not fritted ; but are employed after being simply triturated with water into a thin paste.

The following is the composition of the glaze intended to cover all kinds of figures printed in metallic colours : 26 parts of white felspar are fritted with 6 parts of soda, 2 of nitre, and 1 of borax ; to 20 pounds of this frit, 26 parts of felspar, 20 of white lead, 6 of ground flints, 4 of chalk, 1 of oxide of tin, and a small quantity of oxide of cobalt, to take off the brown cast, and give a faint azure tint, are added.

The following recipe may also be used. Frit together 20 parts of flint glass, 6 of flints, 2 of nitre, and 1 of borax ; add to 12 parts of that frit, 40 parts of white lead, 36 of felspar, 8 of flints, and 6 of flint glass ; then grind the whole together into an uniform cream-consistence paste.

As to the stoneware which is to be painted, it is covered with a glaze composed of 13 parts of the printing-colour frit, to which are added 50 parts of red lead, 40 of white lead, and 12 of flint ; the whole having been ground together.

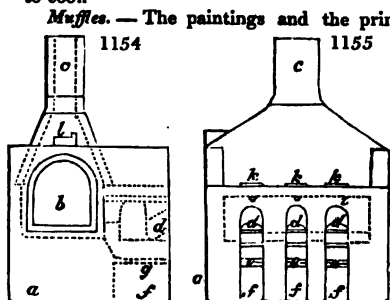
The above compositions produce a very hard glaze, which cannot be scratched by the knife, is not acted upon by vegetable acids, and does no injury to potable or edible articles kept in the vessels covered with it. It preserves for an indefinite time the glassy lustre, and is not subject to crack and exfoliate, like most of the Continental stoneware, made from common pipe-clay.

In order that the saggars in which the articles are baked, after receiving the glaze, may not absorb some of the vitrifying matter, they are themselves coated, as above mentioned, with a glaze composed of 13 parts of common salt, and 30 parts of potash, simply dissolved in water, and brushed over them.

Glaze kiln. — This is usually smaller than the biscuit kiln, and contains no more than 40 or 45 bungs or columns, each composed of 16 or 17 saggars. Those of the first bung rest upon round tiles, and are well luted together with a finely ground fire-clay of only moderate cohesion ; those of the second bung are supported by an additional tile. The lower saggars contain the cream-coloured articles, in which the glaze is softer than that which covers the blue printed ware ; this being always placed in the intervals between the furnaces, and in the uppermost saggars of the columns. The bottom of the kiln, where the glazed ware is not baked, is occupied by printed biscuit ware.

Pyrometric balls of red clay, coated with a very fusible lead enamel, are employed in the English potteries to ascertain the temperature of the glaze kilns. This enamel is so rich, and the clay upon which it is spread, is so fine-grained and compact, that even when exposed for three hours to the briskest flame, it does not lose its lustre. The colour of the clay alone changes, whereby the workman is enabled to judge of the degree of heat within the kiln. At first the balls have a pale red appearance; but they become browner with the increase of the temperature. The balls, when of a slightly dark-red colour, indicate the degree of baking for the hard glaze of pipeclay ware; but if they become dark brown, the glaze will be much too hard, being that suited for *ironstone* ware; lastly, when they acquire an almost black hue, they show a degree of heat suited to the formation of a glaze upon porcelain.

The *glazer* provides himself at each round with a stock of these ball *watches*, reserved from the preceding baking, to serve as objects of comparison; and he never slackens the firing till he has obtained the same depth of shade, or even somewhat more; for it may be remarked, that the more rounds a glaze kiln has made, the browner the balls are apt to become. A new kiln bakes a round of enamel-ware sooner than an old one; as also with less fuel, and at a lower temperature. The watch-balls of these first rounds have generally not so deep a colour as if they were tried in a furnace three or four months old. After this period, cracks begin to appear in the furnaces; the horizontal flues get partially obstructed, the joinings of the brickwork become loose; in consequence of which there is a loss of heat and waste of fuel; the baking of the glaze takes a longer time, and the pyrometric balls assume a different shade from what they had on being taken out of the new kiln, so that the first watches are of no comparable use after two months. The baking of enamel is commenced at a low temperature, and the heat is progressively increased; when it reaches the melting point of the glaze, it must be maintained steadily, and the furnace mouths be carefully looked after, lest the heat should be suffered to fall. The firing is continued 14 hours, and then gradually lowered by slight additions of fuel; after which the kiln is allowed from 5 to 6 hours to cool.



a is the furnace; *b*, the oblong muffle, made of fire-clay, surmounted with a dome pierced with three apertures *k, k, k*, for the escape of the vaporous matters of the colours and volatile oils with which they are ground up; *c* is the chimney; *d, d*, feed-holes, by which the fuel is introduced; *e*, the fire-grate; *f*, the ash-pit; channels are left in the bottom of the furnace to facilitate the passage of the flame beneath the muffle; *g* is a lateral hole, which makes a communication across the furnace in the muffle, enabling the kiln man to ascertain what is passing within; *h, h*, are the lateral chinks for observing the progress of the firing or flame; *l*, is an opening scooped out in the front of the chimney to modify its draught.

The articles which are printed or painted upon the glaze are placed in the muffle without saggars, upon tripods, or movable supports furnished with feet. The muffle being charged, its mouth is closed with a fire-tile well luted round its edges. The fuel is then kindled in the fireplaces *d, d*, and the door of the furnace is closed with bricks, in which a small opening is left for taking out samples, and for examining the interior of the muffle. These sample or trial pieces, attached to a strong iron wire, show the progress of the baking operation. The front of the fireplaces is covered with a sheet-iron plate, which slides to one side, and may be shut whenever the kiln is charged. Soon after the fire is lighted, the flame, which communicates laterally from one furnace to another, envelops the muffle on all sides, and thence rises up the chimney.

Printing of stoneware. — The printing under the stoneware glaze is generally performed by means of cobalt, and has different shades of blue according to the quantity of colouring matter employed. After having subjected this oxide to the processes requisite for its purification, it is mixed with a certain quantity of ground flints and sulphate of baryta, proportioned to the dilution of the shade. These materials are fritted and ground; but before they are used, they must be mixed with a flux consisting of equal parts by weight of flint glass and ground flints, which serves to fix the colour upon the biscuit, so that the immersion in the glaze liquor may not displace the lines printed on, as also to aid in fluxing the cobalt.

The following are the processes usually practised in Staffordshire for printing under the glaze.

The cobalt, or whatever colour is employed, should be ground upon a porphyry slab, with a varnish prepared as follows:— A pint of linseed oil is to be boiled to the consistence of thick honey, along with 4 ounces of rosin, half a pound of tar, and half a pint of oil of amber. This is very tenacious, and can be used only when liquefied by heat; which the printer effects by spreading it upon a hot cast-iron plate.

The printing plates are made of copper, engraved with pretty deep lines in the common way. The printer, with a leather muller, spreads upon the engraved plate, previously heated, his colour, mixed up with the above oil varnish, and removes what is superfluous with a pallet knife; then cleans the plate with a dossil filled with bran, tapping and wiping as if he were removing dust from it. This operation being finished, he takes the paper intended to receive the impression, soaks it with soap-water, and lays it moist upon the copper-plate. The soap makes the paper part more readily from the copper, and the thick ink part more readily from the biscuit. The copper-plate is now passed through the engraver's cylinder press, the proof leaf is lifted off and handed to the women, who cut it into detached pieces, which they apply to the surface of the biscuit. The paper best fitted for this purpose is made entirely of linen rags; it is very thin, of a yellow colour, and unsized, like tissue blotting-paper.

The stoneware biscuit never receives any preparation before being imprinted, the oil of the colour being of such a nature as to fix the figures firmly. The printed paper is pressed and rubbed on with a roll of flannel, about an inch and a half in diameter, and 12 or 15 inches long, bound round with twine, like a roll of tobacco. This is used as a burnisher, one end of it being rested against the shoulder, and the other end being rubbed upon the paper; by which means it transfers all the engraved traces to the biscuit. The piece of biscuit is laid aside for a little, in order that the colour may take fast hold; it is then plunged into water, and the paper is washed away with a sponge.

When the paper is detached, the piece of ware is dipped into a caustic alkaline lye to saponify the oil, after which it is immersed in the glaze liquor, with which the printed figures readily adhere. This process, which is easy to execute, and very economical, is much preferable to the old plan of passing the biscuit into the muffle after it had been printed, for the purpose of fixing and volatilizing the oils. When the paper impression is applied to pieces of porcelain, they are heated before being dipped in the water, because, being already semi-vitrified, the paper sticks more closely to them than to the biscuit, and can be removed only by a hard brush.

The impression above the glaze is done by quite a different process, which dispenses with the use of the press. A quantity of fine clean glue is melted and poured hot upon a large flat dish, so as to form a layer about a quarter of an inch thick, and of the consistence of jelly. When cold it is divided into cakes of the size of the copper-plates it is intended to cover.

The operative (a woman) rubs the engraved copper-plate gently over with linseed oil boiled thick, immediately after which she applies the cake of glue, which she presses down with a silk dossil filled with bran. The cake licks up all the oil out of the engraved lines; it is then cautiously lifted off, and transferred to the surface of the glazed ware which it is intended to print. The glue cake being removed, the enamel surface must be rubbed with a little cotton, whereby the metallic colours are attached only on the lines charged with oil: the piece is then heated under the muffle. The same cake of glue may serve for several impressions.

Ornaments and colouring.— Common stoneware is coloured by means of two kinds of apparatus; the one called the blowing-pot, the other the worming-pot. The ornaments made in relief in France, are made hollow (*intaglio*) in England, by means of a mould engraved in relief, which is passed over the article. The impression which it produces is filled with a thick clay paste, which the workman throws on with the blowing-pot. This is a vessel like a tea-pot, having a spout, but it is hermetically sealed at top with a clay plug, after being filled with the pasty liquor. The workman, by blowing in at the spout, causes the liquor to fly out through a quill pipe which goes down through the clay plug into the liquor. The jet is made to play upon the piece while it is being turned upon the lathe; so that the hollows previously made in it by the mould or stamp are filled with a paste of a colour different from that of the body. When the piece has acquired sufficient firmness to bear working, the excess of the paste is removed by an instrument called a *townas*, till the ornamental figure produced by the stamp be laid bare; in which case merely the colour appears at the bottom of the impression. By passing in this manner several layers of clay liquor of different colours over each other with the blowing-pot, net-work and decorations of different colours and shades are very rapidly produced.

The serpentine or snake pots, established on the same principle, are made of tin plate in three compartments, each containing a different colour. These open at the top of

the vessel in a common orifice, terminated by small quill tubes. On inclining the vessel, the three colours flow out at once in the same proportion at the one orifice, and are let fall upon the piece while it is being slowly turned upon the lathe; whereby curious serpent-like ornaments may be readily obtained. The clay liquor ought to be in keeping with the stoneware paste. The blues succeed best when the ornaments are made with the finer pottery mixtures given above.

Metallic lustres applied to stoneware. — The metallic lustre being applied only to the outer surface of vessels, can have no bad effect on health, whatever substances be employed for the purpose; and as the glaze intended to receive it is sufficiently fusible, from the quantity of lead it contains, there is no need of adding a flux to the metallic coating. The glaze is in this case composed of 60 parts of litharge, 36 of felspar, and 15 of flints.

The silver and platina lustres are usually laid upon a white ground, while those of gold and copper, on account of their transparency, succeed only upon a coloured ground. The dark-coloured stoneware is, however, preferable, as it shows off the colours to most advantage; and thus the shades may be varied by varying the colours of the ornamental figures applied by the blowing-pot.

The gold and platina lustre is almost always applied to a paste body made on purpose, and coated with the above-described lead glaze. This paste is brown, and consists of 4 parts of clay, 4 parts of flints, an equal quantity of kaolin (china clay), and 6 parts of felspar. To make brown figures in relief upon a body of white paste, a liquor is mixed up with this paste, which ought to weigh 26 ounces per pint, in order to unite well with the other paste, and not to exfoliate after it is baked.

Preparation of gold lustre. — Dissolve first in the cold, and then with heat, 48 grains of fine gold in 288 grains of an aqua regia, composed of 1 ounce of nitric acid and 3 ounces of muriatic acid; add to that solution 4½ grains of grain tin, bit by bit; and then pour some of that compound solution into 20 grains of balsam of sulphur diluted with 10 grains of oil of turpentine. The balsam of sulphur is prepared by heating a pint of linseed oil, and 2 ounces of flowers of sulphur, stirring them continually till the mixture begins to boil; it is then cooled, by setting the vessel in cold water; after which it is stirred afresh, and strained through linen. The above ingredients, after being well mixed, are to be allowed to settle for a few minutes; then the remainder of the solution of gold is to be poured in, and the whole is to be triturated till the mass has assumed such a consistence that the pestle will stand upright in it; lastly, there must be added to the mixture 30 grains of oil of turpentine, which being ground in, the gold lustre is ready to be applied. If the lustre is too light or pale, more gold must be added, and if it have not a sufficiently violet or purple tint, more tin must be used.

Platina lustre. — Of this there are two kinds; one similar to polished steel, another lighter and of a silver-white hue. To give stoneware the steel colour with platina, this metal must be dissolved in an aqua regia composed of 2 parts of muriatic acid, and 1 part of nitric. The solution being cooled, and poured into a capsule, there must be added to it, drop by drop, with continual stirring with a glass rod, a *spirit of tar*, composed of equal parts of tar and sulphur boiled in linseed oil and filtered. If the platina solution be too strong, more spirit of tar must be added to it; but if too weak, it must be concentrated by boiling. Thus being brought to the proper pitch, the mixture may be spread over the piece, which being put into the muffle, will take the aspect of steel.

The oxide of platina, by means of which the silver lustre is given to stoneware, is prepared as follows: — After having dissolved to saturation the metal in an aqua regia composed of equal parts of nitric and muriatic acid, the solution is to be poured into a quantity of boiling water. At the same time, a capsule, containing solution of sal-ammoniac is placed upon a sand-bath, and the platina solution being poured into it, the metal will fall down in the form of the well-known yellow precipitate, which is to be washed with cold water till it is perfectly edulcorated, then dried, and put up for use.

This metallic lustre is applied very smoothly by means of a flat camel's hair brush. It is then to be passed through the muffle kiln; but it requires a second application of the platinum to have a sufficient body of lustre. The articles sometimes come black out of the kiln, but they get their proper appearance by being rubbed with cotton.

Platina and gold lustre; by other recipes.

Platina lustre. — Dissolve 1 ounce of platinum in aqua regia formed of 2 parts of muriatic acid and 1 part of nitric acid, with heat upon a sand-bath, till the liquid is reduced to two-thirds of its volume; let it cool; decant into a clean vessel, and pour into it, drop by drop, with constant stirring, some distilled tar, until such a mixture is produced as will give a good result in a trial upon the ware in the kiln. If the lustre be too intense, more tar must be added; if it be too weak, the mixture must be concentrated by further evaporation.

Gold lustre. — Dissolve four shillings' worth of gold in aqua regia with a gentle heat.

To the solution, when cool, add 2 grains of grain tin, which will immediately dissolve. Prepare a mixture of half an ounce of sulphur with a little essence of turpentine, beating them together till they assume the appearance of milk. Pour this mixture into the solution of gold and tin, drop by drop, with continual stirring; and place the whole in a warm situation for some time.

It is absolutely necessary to apply this lustre only upon an enamel or glaze which has already passed through the fire, otherwise the sulphur would tarnish the composition.

These lustres are applied with most advantage upon chocolate and other dark grounds. Much skill is required in their firing, and a perfect acquaintance with the quality of the glaze on which they are applied.

An *iron lustre*, is obtained by dissolving a bit of steel or iron in muriatic acid, mixing this solution with the spirit of tar, and applying it to the surface of the ware.

Aventurine glaze. — Mix a certain quantity of silver leaf with the above-described soft glaze, grind the mixture along with some honey and boiling water, till the metal assume the appearance of fine particles of sand. The glaze being naturally of a yellowish hue, gives a golden tint to the small fragments of silver disseminated through it. Molybdena may also be applied to produce the aventurine aspect.

The *granite-like gold lustre*, is produced by throwing lightly with a brush a few drops of oil of turpentine upon the goods already covered with the preparation for gold lustre. These cause it to separate and appear in particles resembling the surface of granite. When marbling is to be given to stoneware, the lustres of gold, platina, and iron are used at once, which blending in the fusion, form veins like those of marble.

Pottery and stoneware of the Wedgewood colour. — This is a kind of semi-vitrified ware, called *dry bodies*, which is not susceptible of receiving a superficial glaze. This pottery is composed in two ways: the first is with barytic earths, which act as fluxes upon the clays, and form enamels: thus the Wedgewood *jasper* ware is made.

The white vitrifying pastes, fit for receiving all sorts of metallic colours, are composed of 47 parts of sulphate of barytes, 15 of felspar, 26 of Devonshire clay, 6 of sulphate of lime, 15 of flints, and 10 of sulphate of strontites. This composition is capable of receiving the tints of the metallic oxides and of the ochrous metallic earths. Manganese produces the dark purple colour; gold precipitated by tin, a rose colour; antimony, orange; cobalt, different shades of blue; copper is employed for the browns and the dead-leaf greens; nickel gives, with potash, greenish colours.

One per cent. of oxide of cobalt is added; but one half, or even one quarter, of a per cent. would be sufficient to produce the fine Wedgewood blue, when the nickel and manganese constitute 3 per cent. as well as the carbonate of iron. For the blacks of this kind, some English manufacturers mix black oxide of manganese with the black oxide of iron, or with ochre. Nickel and umber afford a fine brown. Carbonate of iron, mixed with bole or *terra di Sienna*, gives a beautiful tint to the paste; as also manganese with cobalt, or cobalt with nickel. Antimony produces a very fine colour when combined with the carbonate of iron in the proportion of 2 per cent., along with the ingredients necessary to form the above-described vitrifying paste.

The following is another vitrifying paste, of a much softer nature than the preceding. Felspar, 30 parts; sulphate of lime, 23; silex, 17; potter's clay, 15; kaolin of Cornwall (china clay), 15; sulphate of baryta, 10.

These vitrifying pastes are very plastic, and may be worked with as much facility as English pipe-clay. The round ware is usually turned upon the lathe. It may, however, be moulded, as the oval pieces always are. The more delicate ornaments are cast in hollow moulds of baked clay, by women and children, and applied with remarkable dexterity upon the turned and moulded articles. The coloured pastes have such an affinity for each other, that the detached ornaments may be applied not only with a little gum water upon the convex and concave forms, but they may be made to adhere without experiencing the least cracking or chinks. The coloured pastes receive only one fire, unless the inner surface is to be glazed; but a gloss is given to the outer surface. The enamel for the interior of the black Wedgewood ware, is composed of 6 parts of red lead, 1 of silex, and 2 ounces of manganese, when the mixture is made in pounds' weight.

The operation called *smearing*, consists in giving an external lustre to the unglazed semi-vitrified ware. The articles do not in this way receive any immersion, nor even the aid of the brush or pencil of the artist; but they require a second fire. The *saggers* are coated with the salt glaze already described. These cases, or *saggers*, communicate by reverberation the lustre so remarkable on the surface of the English stoneware; which one might suppose to be the result of the glaze tub, or of the brush. Occasionally also a very fusible composition is thrown upon the inner surface of the muffle, and 5 or 6 pieces called *refractories* are set in the middle of it, coated with the same composition. The intensity of the heat converts the flux into vapour; a part of

this is condensed upon the surfaces of the contiguous articles, so as to give them the desired brilliancy.

Mortar body, is a paste composed of 6 parts of clay, 3 of felspar, 2 of silex, and 1 of china clay.

White and yellow figures upon dark-coloured grounds are a good deal employed. To produce yellow impressions upon brown stoneware, ochre is ground up with a small quantity of antimony. The flux consists of flint glass and flints in equal weights. The composition for white designs is made by grinding silex up with that flux, and printing it on, as for blue colours, upon brown or other coloured stoneware, which shows off the light hues.

English porcelain or china. — Most of this belongs to the class called tender or soft porcelain by the French and German manufacturers. It is not, therefore, composed simply of *kaolin* and *petuntse*. The English china is generally baked at a much lower heat than that of Sévres, Dresden, and Berlin; and it is covered with a mere glass. Being manufactured upon a prodigious scale, with great economy and certainty, and little expenditure of fuel, it is sold at a very moderate price compared with the foreign porcelain, and in external appearance is now not much inferior.

Some of the English porcelain has been called ironstone china. This is composed usually of 60 parts of Cornish stone, 40 of china slay, and 2 of flint glass; or of 42 of the felspar, the same quantity of clay, 10 parts of flints ground, and 8 of flint glass.

The glaze for the first composition is made with 20 parts of felspar, 15 of flints, 6 of red lead, and 5 of soda, which are fritted together; with 44 parts of the frit, 22 parts of flint glass, and 15 parts of white lead, are ground.

The glaze for the second composition is formed of 8 parts of flint glass, 36 of felspar, 40 of white lead, and 20 of silex (ground flints).

The English manufacturers employ three sorts of compositions for the porcelain biscuit; namely, two compositions not fritted; one of them for the ordinary table service; another for the dessert service and tea dishes; the third, which is fritted, corresponds to the paste used in France for sculpture; and with it all delicate kinds of ornaments are made.

| | First composition. | Second composition. | Third composition. |
|--------------------|--------------------|---------------------|--------------------|
| Ground flints - - | 75 | - - 66 | Lynn sand 150 |
| Calcined bones - - | 180 | - - 100 | - - 300 |
| China clay - - - | 40 | - - 96 | - - 100 |
| Clay - - - - - | 70 | Granite 80 | Potash - 10 |

The glaze for the first two of the preceding compositions consists of, felspar 45, flints 9, borax 21, flint glass 20, nickel 4. After fritting that mixture, add 12 parts of red lead. For the third composition, which is the most fusible, the glaze must receive 12 parts of ground flints, instead of 9; and there should be only 15 parts of borax, instead of 21.

PLAN OF AN ENGLISH POTTERY.

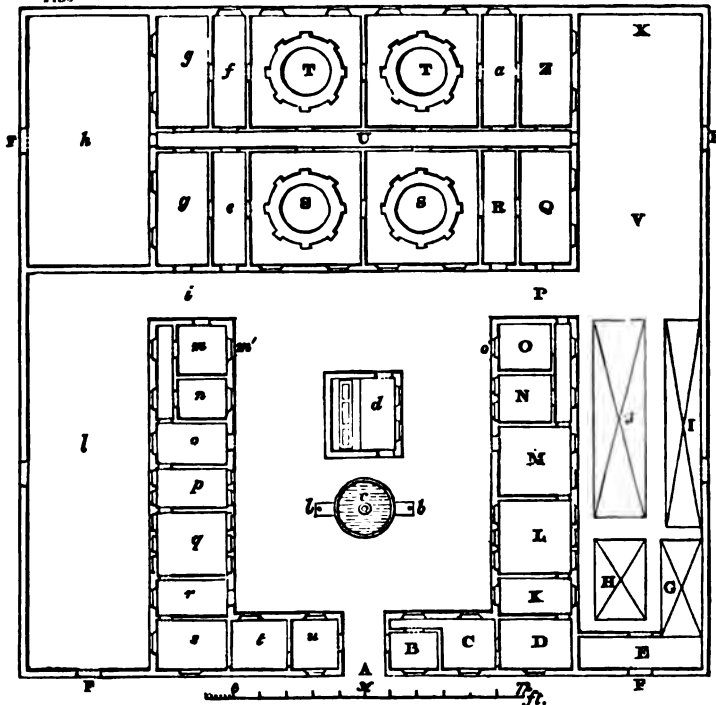
A stoneware manufactory should be placed by the side of a canal or navigable river, because the articles manufactured do not well bear land carriage.

A Staffordshire pottery is usually built as a quadrangle, each side being about 100 feet long, the walls 10 feet high, and the ridge of the roof 5 feet more. The base of the edifice consists of a bed of bricks, 18 inches high, and 16 inches thick; upon which a mud wall in a wooden frame, called *piéz*, is raised. Cellars are formed in front of the buildings, as depôts for the pastes prepared in the establishment. The wall of the yard or court is 9 feet high, and 18 inches thick.

Fig. 1156, A, is the entrance door; B, the porter's lodge; C, a particular warehouse; D, workshop of the plaster-moulder; E, the clay depôt; F, F, large gates, 6 feet 8 inches high; G, the winter evaporation stove; H, the shop for sifting the paste liquors; I, sheds for the paste liquor tubs; J, paste liquor pits; K, workshop for the moulder of hollow ware; L, ditto of the dish or plate moulder; M, the plate drying-stove; N, workshop of the biscuit-printers; O, ditto of the biscuit, with O', a long window; P, passage leading to the paste liquor pits; Q, biscuit warehouse; R, place where the biscuit is cleaned as it comes out of the biscuit kilns, S S; T, T, enamel or glaze kilns; U, long passage; V, space left for supplementary workshops; X, space appointed as a depôt for the sagger fire-clay, as also for making the sagers; Y, the workshop for applying the glaze liquor to the biscuits; A, apartment for cleaning the glazed ware; B, b, pumps; C, basin; D, muffles; E, warehouse for the finished stoneware; F, that of the glazed goods; G, G, another warehouse; H, a large space for the smith's forge, carpenter's shop, packing room, depôt of clays, sagers, &c. The packing and loading of the goods are performed in front of the

warehouse, which has two outlets, in order to facilitate the work; *i*, a passage to the court or yard; *l*, a space for the wooden sheds for keeping hay, clay, and other miscellaneous

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laneous articles, *m*, room for putting the biscuit into the saggars; *m'*, a long window; *n*, workshop with lathes and fly-wheels; *o*, drying-room; *p*, room for mounting or furnishing the pieces; *q*, repairing room; *r*, drying room of the goods roughly turned; *s*, rough turning or blocking-out room; *t*, room for beating the paste or dough; *u*, counting-house.

The declared value of the earthenware exported in 1850 was 999,448*l*.; in 1851, 1,122,571*l*.; the number of pieces being respectively, 75,939,818 and 84,373,367.

There are from 33,000 to 35,000 tons of clay exported annually from Poole, in Dorsetshire, to the English and Scotch potteries. A good deal of clay is also sent from Devonshire and Cornwall.

The Spanish *alcarazas*, or cooling vessels, are made porous, to favour the exudation of water through them, and maintain a constantly moist evaporating surface. Lasteyrie says, that granular sea salt is an ingredient of the paste of the Spanish *alcarazas*; which being expelled partly by the heat of the baking, and partly by the subsequent watery percolation, leaves the body very open. The biscuit should be charged with a considerable proportion of sand, and very moderately fired.

OF PORCELAIN.

Porcelain is a kind of pottery ware whose paste is fine grained, compact, very hard, and faintly translucent; and whose biscuit softens slightly in the kiln. Its ordinary whiteness cannot form a definite character, since there are porcelain pastes variously coloured. There are two species of porcelain, very different in their nature, the essential properties of which it is of consequence to establish; the one is called *hard*, and the other *tender*; important distinctions, the neglect of which has introduced great confusion into many treatises on this elegant manufacture.

Hard porcelain is essentially composed, first, of a natural clay containing some silica, infusible, and preserving its whiteness in a strong heat; this is almost always a true kaolin; secondly, of a flux, consisting of silica and lime, composing a quartzose felspar rock, called *pe-tun-tse*. The glaze of this porcelain, likewise earthy, admits of no metallic substance or alkali.

Tender porcelain, styled also vitreous porcelain, has no relation with the preceding in its composition; it always consists of a vitreous frit, rendered opaque and less fusible by the addition of a calcareous or marly clay. Its glaze is an artificial glass or crystal, into which silica, alkalis, and lead enter.

This porcelain has a more vitreous biscuit, more transparent, a little less hard, and less fragile, but much more fusible than that of the hard porcelain. Its glaze is more glossy, more transparent, a little less white, much tenderer, and more fusible.

The biscuit of the hard porcelain made at the French national manufactory of Sèvres is generally composed of a kaolin clay, and of a decomposed felspar rock; analogous to the china clay of Cornwall, and Cornish stone. Both of the above French materials come from Saint Yriex-la-perche, near Limoges.

After many experiments, the following composition has been adopted for the *service paste* of the royal manufactory of Sèvres; that is, for all the ware which is to be glazed: silica, 59; alumina, 35.2; potash, 2.2; lime, 3.3. The conditions of such a compound are pretty nearly fulfilled by taking from 63 to 70 of the washed kaolin or china clay, 22 to 15 of the felspar; nearly 10 of flint powder, and about 5 of chalk. The glaze is composed solely of solid felspar, calcined, crushed, and then ground fine at the mill. This rock pretty uniformly consists of silica 73, alumina 16.2, potash 8.4, and water 0.6.

The kaolin is washed at the pit, and sent in this state to Sèvres, under the name of *decanted earth*. At the manufactory it is washed and elutriated with care; and its slip is passed through fine sieves. This forms the plastic, infusible, and opaque ingredient to which the substance must be added which gives it a certain degree of fusibility and semi-transparency. The felspar rock used for this purpose, should contain neither dark mica nor iron, either as an oxide or sulphuret. It is calcined to make it crushable, under stamp-pestles driven by machinery, then ground fine in hornstone mills, as represented *figs.* 1154, 1155, 1156, 1157. This pulverulent matter being diffused through water, is mixed in certain proportions, regulated by its quality, with the argillaceous slip. The mixture is deprived of the chief part of its water in shallow plaster pans without heat; and the resulting paste is set aside to ripen, in damp cellars, for many months.

When wanted for use, it is placed in hemispherical pans of plaster, which absorb the redundant moisture; after which it is divided into small lumps, and completely dried. It is next pulverized, moistened a little, and laid on a floor, and trodden upon by a workman marching over it with bare feet in every direction; the parings and fragments of soft moulded articles being intermixed, which improve the plasticity of the whole. When sufficiently tramped, it is made up into masses of the size of a man's head, and kept damp till required.

The dough is now in a state fit for the potter's lathe; but it is much less plastic than stoneware paste, and is more difficult to fashion into the various articles; and hence one cause of the higher price of porcelain.

The round plates and dishes are shaped on plaster moulds; but sometimes the paste is laid on as a crust, and at others it is turned into shape on the lathe. When a crust is to be made, a moistened sheep-skin is spread on a marble table; and over this the dough is extended with a rolling pin, supported on two guide-rules. The crust is then transferred over the plaster mould, by lifting it upon the skin; for it wants tenacity to bear raising by itself. When the piece is to be fashioned on the lathe, a lump of the dough is thrown on the centre of the horizontal wooden disc, and turned into form as directed in treating of stoneware, only it must be left much thicker than in its finished state. After it dries to a certain degree on the plaster mould, the workman replaces it on the lathe, by moistening it on its base with a wet sponge, and finishes its form with an iron tool. A good workman at Sèvres makes no more than from 15 to 20 porcelain plates in a day; whereas an English potter, with two boys, makes from 1000 to 1200 plates of stoneware in the same time. The pieces which are not round, are shaped in plaster moulds, and finished by hand. When the articles are very large, as wash-hand basins, salads, &c., a flat cake is spread above a skin on the marble slab, which is then applied to the mould with the sponge, as for plates; and they are finished by hand.

The projecting pieces, such as handles, beaks, spouts, and ornaments, are moulded and adjusted separately; and are cemented to the bodies of china-ware with slip, or porcelain dough thinned with water. In fact, the mechanical processes with porcelain and the finer stoneware are substantially the same; only they require more time and greater nicety. The least defect in the fabrication, the smallest bit added, an unequal pressure, the cracks of the moulds, although well repaired, and seemingly effaced in the clay shape, re-appear after it is baked. The articles should be allowed to dry very slowly; if hurried but a little, they are liable to be spoiled. When quite dry, they are taken to the kiln.

The kiln for hard porcelain at Sèvres, is a kind of tower in two flats, constructed of

fire-bricks; and resembles, in other respects, the stoneware kiln already figured and described. The fuel is young aspin wood, very dry, and cleft very small; it is put into the apertures of the four outside furnaces or fire-mouths, which discharge their flame into the inside of the kiln; each floor being closed in above, by a dome pierced with holes. The whole is covered in by a roof with an open passage, placed at a proper distance from the uppermost dome. There is, therefore, no chimney proper so called. See **STONE, ARTIFICIAL.**

The raw pieces are put into the upper floor of the kiln; where they receive a heat of about the 60th degree of Wedgewood's pyrometer, and a commencement of baking, which, without altering their shape, or causing a perceptible shrinking of their bulk, makes them completely dry, and gives them sufficient solidity to bear handling. By this preliminary baking, the clay loses its property of forming a paste with water; and the pieces become fit for receiving the glazing coat, as they may be dipped in water without risk of breakage.

The glaze of hard porcelain is a felspar rock: this being ground to a very fine powder, is worked into a paste with water mingled with a little vinegar. All the articles are dipped into this milky liquid for an instant; and as they are very porous, they absorb the water greedily, whereby a layer of the felspar glaze is deposited on their surface, in a nearly dry state, as soon as they are lifted out. Glaze-pap is afterwards applied with a hair brush to the projecting edges, or any points where it had not taken; and the powder is then removed from the part on which the article is to stand, lest it should get fixed to its support in the fire. After these operations it is replaced in the kiln, to be completely baked.

The articles are put into *saggers*, like those of fine stoneware; and this operation is one of the most delicate and expensive in the manufacture of porcelain. The *saggers* are made of the plastic or potter's clay of Abondant, to which about a third part of cement of broken *saggers* has been added.

As the porcelain pieces soften somewhat in the fire, they cannot be set above each other, even were they free from glaze; for the same reason, they cannot be baked on tripods, several of them being in one case, as is done with stoneware. Every piece of porcelain requires a *sagger* for itself. They must, moreover, be placed on a perfectly flat surface, because in softening they would be apt to conform to the irregularities of a rough one. When therefore any piece, a soup plate for example, is to be *saggered*, there is laid on the bottom of the case a perfectly true disc or round cake of stoneware, made of the *sagger* material, and it is secured in its place on three small props of a clay-lute, consisting of potter's clay mixed with a great deal of sand. When the cake is carefully levelled, it is moistened, and dusted over with sand, or coated with a film of fire-clay slip, and the porcelain is carefully set on it. The sand or fire clay hinders it from sticking to the cake. Several small articles may be set on the same cake, provided they do not touch one another.

The *saggers* containing the pieces thus arranged, are piled up in the kiln over each other, in the columnar form, till the whole space be occupied; leaving very moderate intervals between the columns to favour the draught of the fires. The whole being arranged with these precautions, and several others, too minute to be specified here, the door of the kiln is built up with 3 rows of bricks, leaving merely an opening 8 inches square, through which there is access to a *sagger* with the nearest side cut off. In this *sagger* are put fragments of porcelain intended to be withdrawn from time to time, in order to judge of the progress of the baking. These are called *time-pieces* or *watches* (*montres*). This opening into the watches is closed by a stopper of stoneware.

The firing begins by throwing into the furnace-mouths some pretty large pieces of white wood, and the heat is maintained for about 15 hours, gradually raising it by the addition of a larger quantity of the wood, till at the end of that period the kiln has a cherry-red colour within. The heat is now greatly increased by the operation termed *covering the fire*. Instead of throwing billets vertically into the four furnaces, there is placed horizontally on the openings of these furnaces, aspin wood of a sound texture, cleft small, laid in a sloping position. The brisk and long flame which it yields dips into the tunnels, penetrates the kiln, and circulates round the *sagger*-piles. The heat augments rapidly, and, at the end of 13 or 15 hours of this firing, the interior of the kiln is so white, that the watches can hardly be distinguished. The draught, indeed, is so rapid at this time, that one may place his hand on the slope of the wood without feeling incommoded by the heat. Every thing is consumed, no small charcoal remains, smoke is no longer produced, and even the wood-ash is dissipated. It is obvious that the kiln and the *saggers* must be composed of a very refractory clay, in order to resist such a fire. The heat in the Sèvres kilns mounts so high as the 134th degree of Wedgewood.

At the end of 15 or 20 hours of the great fire; that is, after from 30 to 36 hours' firing, the porcelain is baked; as is ascertained by taking out and examining the

watches. The kiln is suffered to cool during 3 or 4 days, and is then opened and discharged. The sand strewed on the cakes to prevent the adhesion of the articles to them, gets attached to their sole, and is removed by friction with a hard sandstone; an operation which one woman can perform for a whole kiln in less than 10 days; and is the last applied to hard porcelain, unless it needs to be returned into the hot kiln to have some defects repaired.

The materials of fine porcelain are very rare; and there would be no advantage in making a gray-white porcelain with coarser and somewhat cheaper materials, for the other sources of expense above detailed, and which are of most consequence, would still exist; while the porcelain, losing much of its brightness, would lose the main part of its value.

Its pap or dough, which requires tedious grinding and manipulation, is also more difficult to work into shapes, in the ratio of 80 to 1, compared to fine stoneware. Each porcelain plate requires a separate sagger; so that 12 occupy in the kiln a space sufficient for at least 98 stoneware plates. The temperature of a hard porcelain kiln being very high, involves a proportionate consumption of fuel and waste of saggars. With 40 steres (cubic metres) of wood, 12,000 stoneware plates may be completely fired, both in the biscuit and glaze kilns; while the same quantity of wood would bake at most only 1000 plates of porcelain.

To these causes of high price, which are constant and essential, we ought to add the numerous accidents to which porcelain is exposed at every step of its preparation, and particularly in the kiln; these accidents damage upwards of one-third of the pieces, and frequently more, when articles of singular form and large dimensions are adventured.

The best English porcelain is made from a mixture of the Cornish kaolin (called china clay), ground flints, ground Cornish stone, and calcined bones in powder, or bone-ash, besides some other materials, according to the fancy of the manufacturers. A liquid pap is made with these materials, compounded in certain proportions, and diluted with water. The fluid part is then withdrawn by the absorbent action of dry stucco basins or pans. The dough, brought to a proper stiffness, and perfectly worked and kneaded on the principles detailed above, is fashioned on the lathe, by the hands of modellers, or by pressure in moulds. The pieces are then baked to the state of biscuit in a kiln, being enclosed, of course, in saggars.

This biscuit has the aspect of white sugar, and being very porous, must receive a vitreous coating. The glaze consists of ground felspar or Cornish stone. Into this, diffused in water, along with a little flint-powder and potash, the biscuit ware is dipped, as already described, under stoneware. The pieces are then fired in the glaze-kiln, care being taken, before putting them into their saggars, to remove the glaze powder from their bottom parts, to prevent their adhesion to the fire-clay vessel.

TENDER PORCELAIN.

Tender porcelain, or soft china-ware, is made with a vitreous frit, rendered less fusible and opaque by an addition of white marl or bone-ash. The frit is, therefore, first prepared. This, at Sèvres, is a composition, made with some nitre, a little sea salt, Alicant barilla, alum, gypsum, and much siliceous sand or ground flints. That mixture is subjected to an incipient pasty fusion in a furnace, where it is stirred about to blend the materials well; and thus a very white spongy frit is obtained. It is pulverized, and to every three parts of it, one of the white marl of Argenteuil is added; and when the whole are well ground, and intimately mixed, the paste of tender porcelain is formed.

As this paste has no tenacity, it cannot bear working till a mucilage of gum or black soap be added, which gives it a kind of plasticity, though even then it will not bear the lathe. Hence it must be fashioned in the press, between two moulds of plaster. The pieces are left thicker than they should be; and when dried, are finished on the lathe with iron tools.

In this state they are baked, without any glaze being applied; but as this porcelain softens far more during the baking than the hard porcelain, it needs to be supported on every side. This is done by baking on earthen moulds all such pieces as can be treated in this way, namely plates, saucers, &c. The pieces are reversed on these moulds, and undergo their shrinkage without losing their form. Beneath other articles, supports of a like paste are laid, which suffer in baking the same contraction as the articles, and of course can serve only once. In this operation saggars are used, in which the pieces and their supports are fired.

The kiln for the tender porcelain at Sèvres is absolutely similar to that for the common stoneware; but it has two floors; and while the biscuit is baked in the lower story, the glaze is fused in the upper one; which causes considerable economy of fuel. The glaze of soft porcelain is a species of glass or crystal prepared on purpose. It is composed of flint, siliceous sand, a little potash or soda, and about two-fifth parts

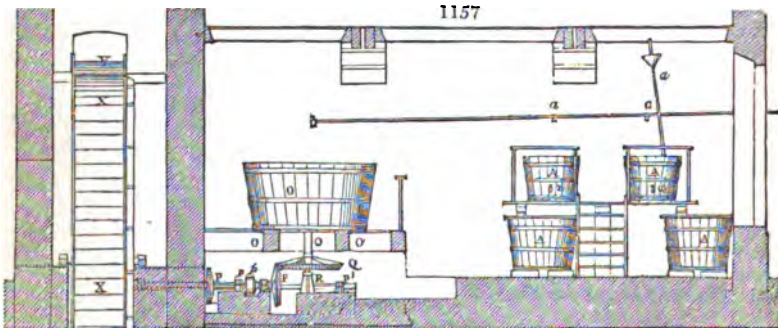
of lead oxide. This mixture is melted in crucibles or pots beneath the kiln. The resulting glass is ground fine, and diffused through water mixed with a little vinegar to the consistence of cream. All the pieces of biscuit are covered with this glazy matter, by pouring this slip over them, since their substance is not absorbent enough to take it on by immersion.

The pieces are encased once more each in a separate sagger, but without any supports; for the heat of the upper floor of the kiln, though adequate to melt the glaze, is not strong enough to soften the biscuit. But as this first vitreous coat is not very equal, a second one is applied, and the pieces are returned to the kiln for the third time. See *STONE, ARTIFICIAL*, for a view of this kiln.

The manufacture of soft porcelain is longer and more difficult than that of hard; its biscuit is dearer, although the raw materials may be found every where; and it furnishes also more refuse. Many of the pieces split asunder, receive fissures, or become deformed in the biscuit-kiln, in spite of the supports; and this vitreous porcelain, moreover, is always yellower, more transparent, and incapable of bearing rapid transitions of temperature, so that even the heat of boiling water frequently cracks it. It possesses some advantages as to painting, and may be made so gaudy and brilliant in its decorations, as to captivate the vulgar eye.

DESCRIPTION OF THE PORCELAIN MILL.

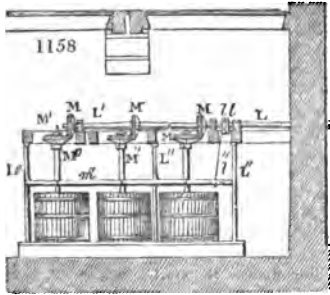
1. The following figures of a felspar and flint mill are taken from plans of apparatus lately constructed by Mr. Hall of Dartford, and erected by him in the royal manufactory of Sèvres. There are two similar sets of apparatus, (1157.), which may be employed together or in succession; composed each of an elevated tub *A*, and of three successive vats



of reception *A'*, and two behind it, whose top edges are upon a lower level than the bottom of the casks *A, A*, to allow of the liquid running out of them with a sufficient slope. A proper charge of kaolin is first put into the cask *A*, then water is gradually run into it by the gutter adapted to the stopcock *a*, after which the mixture is agitated powerfully in every direction by hand with the stirring-bar, which is hung within a hole in the ceiling, and has at its upper end a small tin-plate funnel to prevent dirt or rust from dropping down into the clay. The stirrer may be raised or lowered so as to touch any part of the cask. The semi-fluid mass is left to settle for a few minutes, and then the finer argillaceous pap is run off by the stopcock *a'*, placed a little above the gritty deposit, into the zinc pipe which conveys it into one of the tubs *A'*; but as this semi-liquid matter may still contain some granular substances, it must be passed through a sieve before it is admitted into the tub. There is, therefore, at the spot upon the tub where the zinc pipe terminates, a wire-cloth sieve, of an extremely close texture, to receive the liquid paste. This sieve is shaken upon its support, in order to make it discharge the washed argillaceous kaolin. After the clay has subsided, the water is drawn off from its surface by a zinc syphon. The vats *A'* have covers, to protect their contents from dust. In the pottery factories of England, the agitation is produced by machinery, instead of the hand. A vertical shaft, with horizontal or oblique paddles, is made to revolve in the vats for this purpose.

The small triturating mill is represented in *fig. 1158*. There are three similar grinding-tubs on the same line. The details of the construction are shown in *figs. 1159, 60*, where it is seen to consist principally of a revolving millstone *s* (*fig. 1159*), of a fast or sleeper millstone *s'*, and of a vat *c*, hooped with iron, with its top raised above the upper millstone. The lower block of hornstone rests upon a very firm basis, *b'*; it is surrounded immediately by the strong wooden circle *c*, which slopes out funnel-wise above, in order to throw back the earthy matters as they are pushed up by the attrition

of the stones. That piece is hollowed out, partially to admit the key *c*, opposite to which is the faucet and spigot *c'*, for emptying the tub. When one operation is completed, the key *c* is lifted out at its top; the spigot is then drawn, and the thin paste is run out into vats.

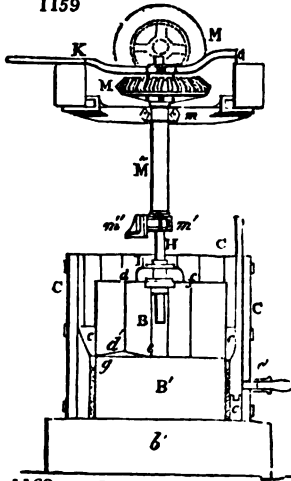


The upper grindstone, *a*, *b*, like the lower one, is about two feet in diameter, and must be cut in a peculiar manner. At first there is scooped out a hollowing in the form of a sector, denoted by *d e f*, *fig. 1160*; the arc *d f* is about one-sixth of the circumference, so that the vacuity of the turning grindstone is one-sixth of its surface; moreover, the stone must be channelled, in order to grind or crush the hard gritty substances. For this purpose, a wedge-shaped groove *d e g*, about an inch and a quarter deep, is made on its under

face, whereby the stone, as it turns in the direction indicated by the arrow, acts with this inclined plane upon all the particles in its course, crushing them and forcing them in between the stones, till they be triturated to an impalpable powder. When the grindstone wears unequally on its lower surface, it is useful to trace upon it little furrows, proceeding from the centre to the circumference, like those shown by the dotted lines *e' e''*. It must, moreover, be indented with rough points by the hammer.

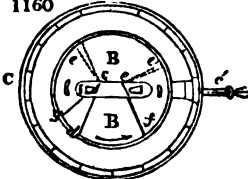
The turning hornstone-block is set in motion by the vertical shaft *n*, which is fixed by the clamp-iron cross *i* to the top of the stone. When the stone is new, its thickness is about 14 inches, and it is made to answer for grinding till it be reduced to about 8 inches, by lowering the clamp *i* upon the shaft, so that it may continue to keep its hold of the stone. The manner in which the grindstones are turned, is obvious from inspection of *fig. 1158*, where the horizontal axis *l*, which receives its impulsion from the great water-wheel, turns the prolonged shaft *l'*, or leaves it at rest, according as the clutch *l, l'*, is locked or opened. This second shaft bears the three bevel wheels *m, m, m*. These work in three corresponding bevel wheels *m' m' m'*, made fast respectively to the

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three vertical shafts of the millstones, which pass through the cast-iron guide tubes *m'' m''*. These are fixed in a truly vertical position by the collar-bar *m'', m''*, *fig. 1159*. In this figure we see at *m* how the strong cross-bar of cast iron is made fast to the wooden beams which support all the upper mechanism of the mill-work. The bearing *m'* is disposed in an analogous manner; but it is supported against two cast-iron columns, shown at *l' l'*, in *fig. 1158*. The guide tubes *m''* are bored smooth for a small distance from each of their extremities, and their interjacent calibre is wider, so that the vertical shafts touch only at two places. It is obvious, that whenever the shaft *l* is set a-going, it necessarily turns the wheels *m* and *m'*, and their guide tubes *m''*; but the vertical shaft may remain either at rest, or revolve, according to the position of the lever click or catch *x*, at the top, which is made to slide upon the shaft, and can let fall a finger into a vertical groove cut in the surface of that shaft. The clamp-fork of the click is thus made to catch upon the horizontal bevel-wheel *m'*, or to release it, according as the lever *x* is lowered or lifted up. Thus each millstone may be thrown out of or into gear at pleasure.

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These stones make upon an average 11 or 12 turns in a minute, corresponding to 3 revolutions of the water-wheel, which moves through a space of 3 feet 4 inches in the second, its outer circumference being 66 feet. The weight of the upper stone, with its iron mountings, is about 6 cwt., when new. The charge of each mill in dry material is 2 cwt.; and the water may be estimated at from one-half to the whole of this weight; whence the total load may be reckoned to be at least 3 cwt.; the stone, by displacement of the magma, loses fully 400 pounds of its weight, and weighs therefore in reality only 2 cwt. It is charged in successive portions, but it is discharged all at once. When the grinding of the siliceous or felspar matters is nearly complete, a remarkable

displacement of the magma, loses fully 400 pounds of its weight, and weighs therefore in reality only 2 cwt. It is charged in successive portions, but it is discharged all at once. When the grinding of the siliceous or felspar matters is nearly complete, a remarkable

phenomenon occurs; the substance precipitates to the bottom, and assumes in a few seconds so strong a degree of cohesion, that it is hardly possible to restore it again to the pasty or magma state; hence if a millstone turns too slowly, or if it be accidentally stopped for a few minutes, the upper stone gets so firmly cemented to the under one, that it is difficult to separate them. It has been discovered, but without knowing why, that a little vinegar added to the water of the magma almost infallibly prevents that sudden stiffening of the deposit and stoppage of the stones. If the mills come to be set fast in this way, the shafts or gearing would be certainly broken, were not some safety provision to be made in the machinery against such accidents. Mr. Hall's contrivance to obviate the above danger is highly ingenious. The clutch *l, l'*, *fig. 1158*, is not a locking crab, fixed in the common way, upon the shaft *z*; but it is composed, as 1162 shown in *figs. 1161, 62, 63, 64*, of a hoop *u*, fixed upon the shaft by means of a key, of a collar *v*, and of a flat ring or washer *x*, with four projections, which are fitted to the collar *v*, by four bolts *y*. *Fig. 1162*, represents the collar *v* seen in front; that is, by the face which carries the clutch teeth; and *fig. 1163* represents its other face, which receives the flat ring *x*, *fig. 1164*, in four notches corresponding to the four projections of the washer-ring. Since the ring *u* is fixed upon the shaft *z*, and necessarily turns with it, it has the two other pieces at its disposal, namely the collar *v*, and the washer *x*, because they are always connected

with it by the four bolts *y*, so as to turn with the ring *u*, when the resistance they encounter upon the shaft *z'* is not too great, and to remain at rest, letting the ring *u* turn by itself, when that resistance increases to a certain pitch. To give this degree of friction, we need only interpose the leather washers *x, x'*, *fig. 1161*; and now as the collar *coupling-box, v*, slides pretty freely upon the ring *u*, it is obvious that by tightening more or less the screw bolts *y*, these washers will become as it were a lateral brake, to tighten more or less the bearing of the ring *u*, to which they are applied: by regulating this pressure, every thing may be easily adjusted. When the resistance becomes too great, the leather washers, pressed upon one side by the collar *v*, of the washer *x*, and rubbed upon the other side by the prominence of the ring *u*, get heated to such a degree, that they are apt to become carbonized, and require replacement.

This safety clutch may be recommended to the notice of mechanics, as susceptible of beneficial application in a variety of circumstances.

GREAT PORCELAIN MILL.

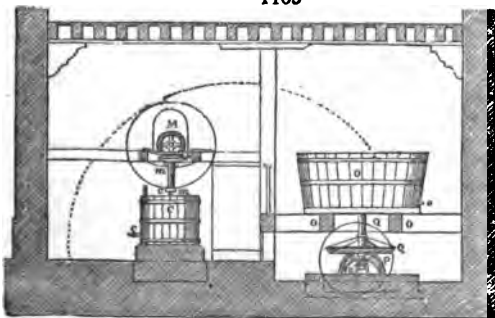
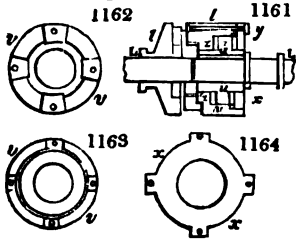
The large felspar and kaolin mill, made by Mr. Hall, for Sèvres, has a flat bed of hornstone, in one block, laid at the bottom of a great tub, hooped strongly with iron. In most of the English potteries, however, that bed consists of several flat pieces of chert or hornstone, laid level with each other. There is, as usual, an spigot and faucet at the side, for drawing off the liquid paste. The whole system of the mechanism is very substantial, and is supported by wooden beams.

The following is the manner of turning the upper blocks. In *fig. 1157*, the main horizontal shaft *r* bears at one of its extremities a toothed wheel, usually mounted upon the periphery of the great water-wheel (*fig. 1165*, shows this toothed wheel by a dotted line) at its other end; *r* carries the fixed portion *p* of a coupling-box, similar to the one just described as belonging to the little mill. On the prolongation of *r*, there is a second shaft *r'*, which bears the movable portion of that box, and an upright bevel wheel *r''*.

Lastly, in *figs. 1157. & 1165*, there is shown the vertical shaft *q*, which carries at its upper end a large horizontal cast-iron wheel *q'*, not seen in

this view, because it is sunk within the upper surface of the turning hornstone, like the clamp *d, f*, in *fig. 1159*. At the lower end of the shaft *q*, there is the bevel wheel *q''*, which receives motion from the wheel *r''*, *fig. 1157*.

The shaft *r* always revolves with the water-wheel; but transmits its motion to the



shaft *r'* only when the latter is thrown into gear with the coupling-box *p'*, by means of its forked lever. Then the bevel wheel *r'* turns round with the shaft *r'*, and communicates its rotation to the bevel wheel *q''*, which transmits it to the shaft *q*, and to the large cast-iron wheel, which is sunk into the upper surface of the revolving hornstone.

The shaft *q* is supported and centred by a simple and solid adjustment; at its lower part, it rests in a step *a*, which is supported upon a cast-iron arch *a'*, seen in profile in *fig. 1157.*; its base is solidly fixed by four strong bolts. Four set screws above *a*, *fig. 1157.*, serve to set the shaft *q* truly perpendicular: thus supported, and held securely at its lower end, in the step at *a*, *figs. 1157. and 1165.*, it is embraced near the upper end by a brass bush or collar, composed of two pieces, which may be drawn closer together by means of a screw. This collar is set into the summit of a great truncated cone of cast-iron, which rises within the tub through two-thirds of the thickness of the hornstone bed; having its base firmly fixed by bolts to the bottom of the tub, and having a brass collet to secure its top. The iron cone is cased in wood. When all these pieces are well adjusted and properly screwed up, the shaft *q* revolves without the least vacillation, and carries round with it the large iron wheel *q'*, cast in one piece, and which consists of an outer rim, three arms or radii, and a strong central nave, made fast by a key to the top of the shaft *q*, and resting upon a shoulder nicely turned to receive it. Upon each of the three arms, there are adjusted, with bolts, three upright substantial bars of oak, which descend vertically through the body of the revolving mill to within a small distance of the bedstone; and upon each of the three arcs of that wheel-ring, comprised between its three strong arms, there are adjusted, in like manner, five similar uprights, which fit into hollows out in the periphery of the moving stone. They ought to be cut to a level at their lower part, to suit the slope of the bottom of the tub *o*, *figs. 1157. and 1165.*, so as to glide past it pretty closely, without touching.

The speed of this large mill is eight revolutions in the minute. The turning hornstone describes a mean circumference of 141½ inches (its diameter being 45 inches), and of course moves through about 100 feet per second. The tub *o*, is 52 inches wide at bottom, 56 at the surface of the sleeper block (which is 16 inches thick), and 64 at top, inside measure. It sometimes happens that the millstone throws the pasty mixture out of the vessel, though its top is 6 inches under the lip of the tub *o*; an inconvenience which can be obviated only by making the pap a little thicker; that is, by allowing only from 25 to 30 per cent. of water; then its density becomes nearly equal to 2.00, while that of the millstones themselves is only 2.7; whence, supposing them to weigh only 2 cwt., there would remain an effective weight of less than ½ cwt. for pressing upon the bottom and grinding the granular particles. This weight appears to be somewhat too small to do much work in a short time; and therefore it would be better to increase the quantity of water, and put covers of some convenient form over the tubs. It is estimated that this mill will grind nearly 5 cwt. of hard kaolin or felspar gravel, in 24 hours, into a proper pap.

To the preceding methodical account of the porcelain manufacture, I shall now subjoin some practical details relative to certain styles of work, with comparisons between the methods pursued in this country and upon the Continent, but chiefly by our jealous rivals the French.

The blue printed ware of England has been hitherto a hopeless object of emulation in France. M. Alexandre Brongniart, membre de l'Institut, and director of the *Manufacture Royal de Sèvres*, characterizes the French imitations of the *Fayence fine, ou Anglaise*, in the following terms: "Les défauts de cette poterie, qui tiennent à sa nature, sont de ne pouvoir aller sur le feu pour les usages domestiques, et d'avoir un vernis tendre, qui se laisse aisément entamer par les instruments d'acier et de fer. Mais lorsque cette poterie est mal fabriquée, ou fabriquée avec une économie mal entendue, ses défauts deviennent bien plus graves; son vernis jaunâtre et tendre se saïlle souvent; il se laisse entamer ou user avec la plus grande facilité par les instruments de fer, ou par l'usage ordinaire. Les fissures que ce tressaillement ou ces rayures ouvrent dans le vernis permettent aux matières grasses de pénétrer dans le biscuit, que dans les poteries affectées de ce défaut, a presque toujours une texture lâche; les pièces se salissent, s'empuantissent, et se brisent même avec la plus grande facilité."*

What a glaze, to be scratched or grooved with soft iron; to fly off in scales, so as to let grease soak into the biscuit or body of the ware; to become foul, stink, and break with the utmost ease! The refuse crockery of the coarsest pottery works in the United Kingdom would hardly deserve such censure.

In the minutes of evidence of the *Enquête Ministérielle*, published in 1835, M. de Saint Cricq and Lebeuf, large manufacturers of pottery-ware at Creil and Montereau, give a very gratifying account of the English stoneware manufacture. They declare that the English possess magnificent mines of potter's clay, many leagues in extent; while those of the

* Dict. Technologique, tom. xvii., article Poteries, p. 263.

French are mere patches or *pots*. Besides, England, they say, having upwards of 200 potteries, can constantly employ a great many public flint-mills, and thereby obtain that indispensable material of the best quality, and at the lowest rate. "The mill erected by M. Brongniart, at Sèvres, does its work at twice the price of the English mills. The fuel costs in England one-fourth of what it does in France. The expense of a kiln-round, in the latter country, is 200 francs; while in the former it is not more than 60." After a two-months tour among the English potteries, these gentlemen made the following additional observations to their first official statement:—

"The clay, which goes by water carriage from the counties of Devon and Dorset, into Staffordshire, to supply more than 200 potteries, clustered together, is delivered to them at a cost of 4 francs (*Ss. 2d.*) the 100 kilogrammes (2 cwt.); at Creil, it costs 4*f.* 50*c.*, and at Mintereau, only 2*f.* 40*c.* There appears, therefore, to be no essential difference in the price of the clay; but the quality of the English is much superior, being incontestably whiter, purer, more homogeneous, and not turning red at a high heat, like the French." The grinding of the flints costs the English potter 4*d.* per 100 kilos., and the French 6*d.*; but as that of the latter is in general ground dry, it is a coarser article. The kaolin, or china clay, is imported from Cornwall for the use of many French potteries; but the transport of merchandise is so ill managed in France, that while 2 cwt. cost in Staffordshire only 8*f.* 75*c.* (about 7*s.* 1*d.*), they cost 12*f.* at Creil, and 13*f.* 50*c.* at Montereau. The white lead and massicot, so much employed for glazes, are 62 per cent. dearer to the French potters than the English. As no French mill has succeeded in making unsized paper fit for printing upon stoneware, our potters are under the necessity of fetching it from England; and, under favour of our own custom-house, are allowed to import it at a duty of 16*f.* per 100 kilogrammes, or about 8*d.* per pound English. No large stock of materials need be kept by the English, because every article may be had when wanted from its appropriate wholesale dealers; but the case is quite different with the French, whose stocks, even in small works, can never safely be less in value than 150,000*f.* or 200,000*f.*; constituting a loss to them, in interest upon their capital, of from 7,500*f.* to 10,000*f.* per annum. The capital sunk in buildings is far less in England than in France, in consequence of the different styles of erecting stoneware factories in the two countries. M. de Saint Cricq informs us, that Mr. Clewes, of Shelton, rents his works for 10,000*f.* (380*l.*) per annum; while the similar ones of Creil and Montereau, in France, have cost each a capital outlay of from 500,000*f.* to 600,000*f.*, and in which the products are not more than one half of Mr. Clewes'. "This forms a balance against us," says M. St. C., "of about 20,000*f.* per annum; or nearly 800*l.* sterling. Finally, we have the most formidable rival to our potteries in the extreme dexterity of the English artisans. An enormous fabrication permits the manufacturers to employ the same workmen during the whole year upon the same piece; thus I have seen at Shelton a furnisher, for sixpence, turn off 100 pieces, which cost at Creil and Montereau 30 sous (1*s.* 2*d.*); yet the English workman earns 18*f.* 75*c.* a week, while the French never earns more than 15*f.* I have likewise seen an English moulder expert enough to make 25 waterpots a day, which, at the rate of 2*d.* a piece, bring him 4*s.* 2*d.* of daily wages; while the French moulder, at daily wages also of 4*s.* 2*d.*, turns out of his hands only 7, or at most 8 pots. In regard to hollow wares, the English may be fairly allowed to have an advantage over us, in the cost of labour, of 100 per cent.; which they derive from the circumstance, that there are in Staffordshire 60,000 operatives, men, women, and children, entirely dedicated to the stoneware manufacture; concentrating all their energies within a space of 10 square leagues. Hence a most auspicious choice of good practical potters, which cannot be found in France."

M. Saint Amans, a French gentleman, who spent some years in Staffordshire, and has lately erected a large pottery in France, says the English surpass all other nations in manufacturing a peculiar stoneware, remarkable for its lightness, strength, and elegance; as also in printing blue figures upon it of every tint, equal to that of the Chinese, by processes of singular facility and promptitude. After the biscuit is taken out of the kiln, the fresh impression of the engraving is transferred to it from thin unsized paper, previously immersed in strong soap water; the ink for this purpose being a compound of arseniate of cobalt with a flux, ground up with properly boiled linseed oil. The copper-plates are formed by the graving tool with deeper or shallower lines according to the variable depth of shades in the design. The cobalt pigment, on melting, spreads so as to give the soft effect of water-colour drawing. The paper being still moist, is readily applied to the slightly rough and adhesive surface of the biscuit, and may be rubbed on more closely by a dossil of flannel. The piece is then dipped in a tub of water, whereby the paper gets soft, and may be easily removed, leaving upon the pottery the pigment of the engraved impression. After being gently dried, the piece is dipped into the glaze mixture, and put into the enamel oven.

Composition of the Earthy Mixtures.

The basis of the English stoneware is, as formerly stated, a bluish clay, brought from Dorsetshire and Devonshire, which lies at the depth of from 25 to 30 feet beneath the surface. It is composed of about 24 parts of alumina, and 76 of silica, with some other ingredients in very small proportions. This clay is very refractory in high heats, a property which, joined to its whiteness when burned, renders it peculiarly valuable for pottery. It is also the basis of all the yellow biscuit ware called *cream colour*, and in general of what is called the *printing body*; as also for the semi-vitrified porcelain of Wedgwood's invention, and of the tender porcelain.

The constituents of the stoneware are, that clay, the powder of calcined flints, and of the decomposed felspar called Cornish stone. The proportions are varied by the different manufacturers. The following are those generally adopted in one of the principal establishments of Staffordshire:—

| | | | | | |
|--|---|---|---|---|----------|
| For <i>cream colour</i> , Silex or ground flints | - | - | - | - | 20 parts |
| Clay | - | - | - | - | 100 |
| Cornish stone | - | - | - | - | 2 |

Composition of the Paste for receiving the Printing Body under the Glaze.

For this purpose the proportions of the flint and the felspar must be increased. The substances are mixed separately with water into the consistence of a thick cream, which weighs per pint, for the flints 32 ounces, and for the Cornish stone 28. The china clay of Cornwall is added to the same mixture of flint and felspar, when a finer pottery or porcelain is required. That clay-cream weighs 24 ounces per pint. These 24 ounces in weight are reduced to one-third of their bulk by evaporation. The pint of dry Cornish clay weighs 17 ounces, and in its first pasty state 24, as just stated. The dry flint powder weighs 14½ ounces per pint; which when made into a cream weighs 32 ounces. To 40 measures of Devonshire clay-cream there are added,

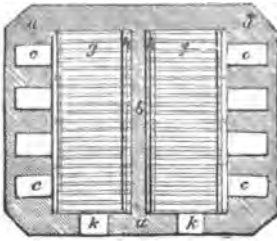
| | |
|------------------------------|----------------------|
| 13 measures of flint liquor. | |
| 12 — | Cornish clay ditto. |
| 1 — | Cornish stone ditto. |

The whole are well mixed by proper agitation, half dried in the *troughs* of the slip-kiln, and then subjected to the machine for cutting up the clay into junks. The above paste, when baked, is very white, hard, sonorous, and susceptible of receiving all sorts of impressions from the paper engravings. When the silica is mixed with the alumina in the above proportions, it forms a compact ware, and the impression remains fixed between the biscuit and the glaze, without communicating to either any portion of the tint of the metallic colour employed in the engraver's press. The felspar gives strength to the biscuit, and renders it sonorous after being baked; while the china clay has the double advantage of imparting an agreeable whiteness and great closeness of grain.

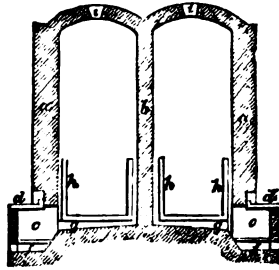
Dead silver on porcelain is much more easily affected by fuliginous vapours than burnished. It may, however, by the following process be completely protected. The silver must be dissolved in very dilute acid, and slowly precipitated; and the metallic precipitate well washed. The silver is then laid (in wavy lines?) upon the porcelain before being coloured (or if coloured, the colour must not be any preparation of gold) in a pasty state and left for 24 hours, at the expiration of which time the gold is to be laid on and the article placed in a moderate heat. The layer of gold must be very thin, and laid on with a brush over the silver before firing it; when by the aid of a flux and a cherry red heat the two metals are fixed on the porcelain.—*Newton's Journal*, xxxi. 128.

POTTER'S OVEN. A patent was obtained in August, 1842, by Mr. W. Ridgway, for the following construction of oven, in which the flames from the fire-places are conveyed by parallel flues, both horizontal and vertical, so as to reverberate the whole of the flame and heat upon the goods after its ascension from the flues. His oven is built square instead of round, a fire-proof partition wall being built across the middle of it, dividing it into two chambers, which are covered in by two parallel arches. The fire-places are built in the two sides of the oven opposite to the partition wall: from which fire-places narrow flues rise in the inner face of the wall, and distribute the flame in a sheet equally over the whole of its surface. The other portion of the heat is conveyed by many parallel or diverging horizontal flues, under and across the floor or hearth of the oven, to the middle or partition wall; over the surface of which the flame which ascends from the numerous flues in immediate contact with the wall is equally distributed. This sheet of ascending flame strikes the shoulder of the arch, and is reverberated from the seggars beneath, till it meets the flame reverberated from the opposite side of the arch, and both escape at the top of the oven. The same construction is also applied to the opposite chamber. In *figs.* 1166, 67, *a*, represents the square walls or body of the oven; *b*, the partition wall; *c*, the fire-places or furnaces

1166



1167



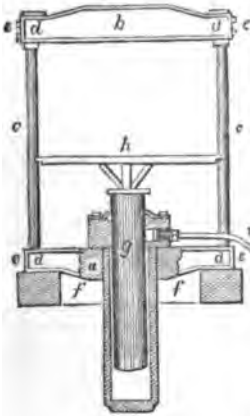
with their iron boilers; *d*, the mouths of the furnaces for introducing the fuel; *f*, the ash-pits; *g*, the horizontal flues under the hearth of the oven; *h*, the vertical flues; *i*, the vents in the top of the arches; and *k*, the entrances to the chambers of the ovens.

PRECIPITATE, is any matter separated in minute particles from the bosom of a fluid, which subsides to the bottom of the vessel in a pulverulent form.

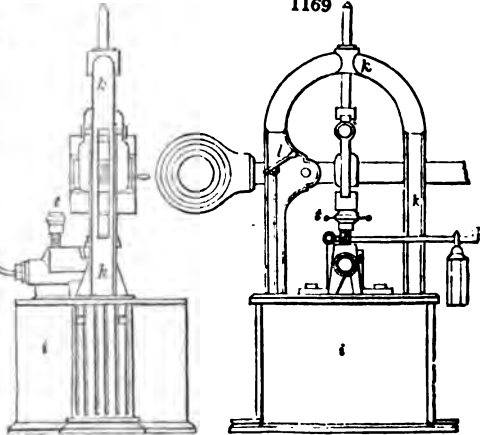
PRECIPITATION, is the actual subsidence of a precipitate.

PRESS, HYDRAULIC. Though the explanation of the principles of this powerful machine belongs to a work upon mechanical engineering, rather than to one upon

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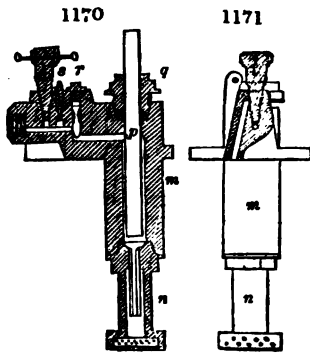
1169



manufactures, yet as it is often referred to in this volume, a brief description of it cannot be unacceptable to many of my readers.

The framing consists of two stout cast-iron plates *a, b*, which are strengthened by projecting ribs, not seen in the section, *fig.* 1168. The top or crown plate *b*, and the base-plate *a, a*, are bound most firmly together by 4 cylinders of the best wrought iron, *c, c*, which pass up through holes near the ends of the said plates, and are fast wedged in them. The flat pieces *e, e*, are screwed to the ends of the crown and base plates, so as to bind the columns laterally. *f*, is the hollow cylinder of the press, which, as well as the ram *g*, is made of cast-iron. The upper part of the cavity of the cylinder is cast narrow, but is truly and smoothly rounded at the boring-mill, so as to fit pretty closely round a well-turned ram or piston; the under part of it is left somewhat wider in the casting. A stout cup of leather, perforated in the middle, is put upon the ram, and serves as a valve to render the neck of the cylinder perfectly water-tight by filling up the space between it and the ram; and since the mouth of the cup is turned downwards, the greater the pressure of water upwards, the more forcibly are the edges of the leather valve pressed against the insides of the cylinder, and the tighter does the joint become. This was Bramah's beautiful invention.

Upon the top of the ram, the press-plate, or table, strengthened with projecting ridges, rests, which is commonly called the follower, because it follows the ram closely in its



descent. This plate has a half-round hole at each of its four corners, corresponding to the shape of the four iron columns along which it glides in its up-and-down motions of compression and relaxation.

h, h, Figs. 1168, and 1169, is the framing of a force pump with a narrow barrel; *i* is the well for containing water to supply the pump. To spare room in the engraving, the pump is set close to the press, but it may be removed to any convenient distance by lengthening the water-pipe *u*, which connects the discharge of the force pump with the inside of the cylinder of the press. *Fig. 1170,* is a section of the pump and its valves. The pump *m*, is of bronze; the suction pipe *n* has a conical valve with a long tail; the solid piston or plunger *p*, is smaller than the barrel in which it plays, and passes at its top through a stuffing-box *q*; *r* is the pressure-valve, *s* is the safety-valve, which, in *fig. 1169,* is seen to be loaded with a weighted lever; *t* is the discharge-valve, for letting the water escape from the cylinder beneath the ram, back into the well. See the winding passages in *fig. 1171.* *u* is the tube which conveys the water from the pump into the press-cylinder. In *fig. 1169,* two centres of motion for the pump-lever are shown. By shifting the bolt into the centre nearest the pump-rod, the mechanical advantage of the workman may be doubled. Two pumps are generally mounted in one frame for one hydraulic press: the larger to give a rapid motion to the ram at the beginning, when the resistance is small; the smaller to give a slower but more powerful impulsion, when the resistance is much increased. A pressure of 500 tons may be obtained from a well-made hydraulic press with a ten-inch ram, and a two and a one inch set of pumps. See STEAMING PRESSES.

PRINCE'S METAL, or Prince Rupert's metal, is a modification of brass.

PRINTED FABRICS, *whether dyed, felted or woven.* — *Exhibition, Section 3, Class 18.* The colour printer and dyer form the subjects represented by this class. The arts practised by them have made most important progress during late years. At first, taught only by a long and varied experience, the importer of colour was restricted to the use of a few comparatively simple substances for the extraction of colour, and its application to various fabrics. But since chemistry has been allowed to occupy a part of the attention of the manufacturer, a very different result has arisen. The indications of experience are confirmed by the teachings of philosophy, and in a large number of instances a vast economy of material, time, and labour has been effected. In addition, chemistry has brought to light new compounds and new means of obtaining dyes and colours of great brilliance from a few simple combinations. It is consequently now almost universal to find that attached to the extensive works of the dyer and colour-printer, is a large laboratory fitted up for chemical investigations, and the processes developed in which are often the source of a very great commercial prosperity.

The print works of Lancashire, and particularly of Manchester and its vicinity, form the most extensive sources of printed and dyed articles. Glasgow, Carlisle, Crayford, Paisley, and other places, also contain important works of a somewhat similar description. The origin of cotton printing appears to have taken place in the vicinity of the metropolis in 1675.

During the last half century, a surprising development of printing in colour and dyeing has taken place. It is estimated that, at its commencement, the annual quantity of cotton printed was 32,869,729 yards. But in 1830, this quantity had attained the enormous increase of 347,450,299 yards; and it has since still further increased. The print works of Lancashire, and other places, form a surprising spectacle of the operation of chemical and mechanical forces on the great scale. That which was formerly the labour of weeks is now performed in a day. A piece of cloth is printed at the rate of hundreds of yards in a day. On one side of a machine-room it ascends moist, with colour from the engraved copper cylinder; on the other hand it descends dried, ready for the final processes. The printing machines are marvels of ingenuity; the pattern is applied by the engraved surface of one or more copper cylinders, which have received the pattern from a small steel cylinder, or "mill" capable of impressing several with the same design, and thus saving the cost of repeated engraving. At first only one colour could be applied; now from six, or even eight and ten colours, are applied in constant succession. These machines perform their work with great accuracy and speed, and produce all the commoner patterns seen in daily use; but hand labour is still employed, even in these works, for fine or complicated work, and more particularly for printing mousseline-de-laine dresses, &c. The goods thus printed are exported in immense quantities to all parts of the world, a large portion being also retained for home use. For

foreign countries a certain peculiarity of chromatic arrangement is necessary, in order to render the articles adapted to the taste of purchasers.

The art of the dyer in towns is a manufacture on a smaller scale, and carried on generally in small establishments devoted to that purpose. But extensive dye-works exist, which are employed in imparting various colours to cloth, &c., on the great scale. To the prosperous pursuit of either of these arts, it is beginning to be more and more widely felt that an enlightened and philosophical mind is of the first consequence.

Formerly the application of coloured designs to fabrics of various kinds was entirely effected by what is called block-printing, and which in fact closely resembles type printing. A block of wood or metal, or a combination of both, being engraved with the pattern, received the colour by the ordinary means, and this was then transferred by hand to the fabric. For every different colour a different block was required, and in complicated patterns, with many colours, the process was excessively tedious. It is, however, still largely employed, where great care in the application of the colour and sharpness of definition in the pattern is required, but block-printing can only be remunerative in the better descriptions of goods, as the infinitely more rapid and economical process of the cylinder printing has almost superseded it for the production of those of commoner kinds.

71. *Hammersley, J. A., Principal of the School of Design, Manchester, Designer.* Picture in oil colours, showing the principles upon which floral forms are adapted to designs for textile fabrics; exhibiting a central picture of a composition of flowers, imitated from nature, surrounded by 200 geometrical spaces, each containing a separate design, and showing the mode of applying these flowers to manufactures.

For textile fabrics, natural flowers have been represented under conventional forms; so that, without departing from the original type, the character of design may not be pictorial. The patterns of eastern chintzes are but fantastic imitations of flowers; and the pure taste of ancient Greece discarded from female dress all ornament but that of a flat character: where borders of the vine or ivy-leaf, or of the honeysuckle, have been adopted, they are flat. The oriental cashmere style, the stuffs and carpets of Persia and Turkey, the tartan of the Scot, the arabesques of ancient Rome, and Moorish decoration, while admitting of every variety of beauty in design or colour, are examples of a flat as opposed to a relieved pictorial style of ornament.

PRINTING. Galvanography, in the short interval which has elapsed since its first appearance, has been divided into two methods. The first consists in the composition being executed by the artist himself with colour (roasted terra di Sienna, or black-lead and linseed oil) and the ordinary brush, in the same manner as an Indian-ink drawing upon a silvered-copper plate, which is then placed in the galvanoplastic apparatus, in order to obtain a copy of the raised drawing. The copy, or sunk plate, thus obtained, is touched up with the usual copper-plate engraving tools, and the light and shade improved, and then serves for printing from: it can of course, by means of the galvanic apparatus, be multiplied to any desired extent. This method certainly possesses the advantage of allowing rapidity in execution and great freedom of treatment. In the second method of galvanography, the outlines of the given drawing are etched in the usual manner, the various tones of the picture laid on with the roulette, and a galvanoplastic copy of this sunk plate is then produced. On this second (raised) plate, the artist completes his picture by means of chalk and Indian ink, and puts in the lights and shades, &c. From this a second galvanoplastic copy is produced. This second copy, or sunk plate, the third plate in the order of procedure, serves, after being touched up, for printing from in the copper-plate press.

PRINTING INK. (*Encre d'imprimerie, Fr. ; Buchdruckerfarbe, Germ.*) After reviewing the different prescriptions given by Moxon, Breton, Papillon, Lewis, those in Nicholson's and the Messrs. Aikins' Dictionaries, in Rees' Cyclopædia, and in the French Printer's Manual, Mr. Savage* says, that the Encyclopædia Britannica is the only work, to his knowledge, which has given a recipe by which a printing ink might be made, that could be used, though it would be of inferior quality, as acknowledged by the editor; for it specifies neither the qualities of the materials, nor their due proportions. The fine black ink made by Mr. Savage has, he informs us, been pronounced by some of our first printers to be unrivalled; and has procured for him the large medal from the Society for the Encouragement of Arts.

1. *Linseed oil.*—Mr. S. says that the linseed oil, however long boiled, unless set fire to, cannot be brought into a proper state for forming printing ink; and that the flame may be most readily extinguished by the application of a pretty tight tin cover to the top of the boiler, which should never be more than half full. The French prefer nut oil to linseed; but if the latter be old, it is fully as good, and much cheaper, in this country at least.

2. *Black rosin* is an important article in the composition of good ink; as by melting

* In his work on the Preparation of Printing Ink; 8vo. London, 1832.

it in the oil, when that ingredient is sufficiently boiled and burnt, the two combine, and form a compound approximating to a natural balsam, like that of Canada, which is itself one of the best varnishes that can be used for printing ink.

3. *Soap*. — This is a most important ingredient in the printer's ink, which is not even mentioned in any of the recipes prior to that in the *Encyclopædia Britannica*. For want of soap, ink accumulates upon the face of the types, so as completely to clog them up after comparatively few impressions have been taken; it will not wash off without alkaline lyes, and it skins over very soon in the pot. Yellow rosin soap is the best for black inks; for those of light and delicate shades, white curd soap is preferable. Too much soap is apt to render the impression irregular, and to prevent the ink from drying quickly. The proper proportion has been hit, when the ink works clean, without clogging the surface of the types.

4. *Lamp black*. — The vegetable lamp black, sold in firkins, takes by far the most varnish, and answers for making the best ink. See BLACK.

5. *Ivory black* is too heavy to be used alone as a pigment for printing ink; but it may be added with advantage by grinding a little of it upon a muller with the lamp black, for certain purposes; for instance, if an engraving on wood is required to be printed so as to produce the best possible effect.

6. *Indigo* alone, or with an equal weight of prussian blue, added in small proportion, takes off the brown tones of certain lamp-black inks. Mr. Savage recommends a little Indian red to be ground in with the indigo and prussian blue, to give a rich tone to the black ink,

7. *Balsam of capivi*, as sold by Mr. Allen, Plough-court, Lombard-street, mixed, by a stone and a muller, with a due proportion of soap and pigment, forms an extemporaneous ink, which the printer may employ very advantageously when he wishes to execute a job in a peculiarly neat manner. Canada balsam does not answer quite so well.

After the smoke begins to rise from the boiling oil, a bit of burning paper stuck in the cleft end of a long stick, should be applied to the surface, to set it on fire, as soon as the vapour will burn; and the flame should be allowed to continue (the pot being meanwhile removed from over the fire, or the fire taken from under the pot,) till a sample of the varnish, cooled upon a pallet-knife, draws out into strings of about half an inch long between the fingers. To six quarts of linseed oil thus treated, six pounds of rosin should be gradually added, as soon as the froth of the ebullition has subsided. Whenever the rosin is dissolved, one pound and three quarters of dry brown soap, of the best quality, cut into slices, is to be introduced cautiously, for its water of combination causes a violent intumescence. Both the rosin and soap should be well stirred with the spatula. The pot is to be now set upon the fire, in order to complete the combination of all the constituents.

Put next of well ground indigo and prussian blue, each 2½ ounces, into an earthen pan, sufficiently large to hold all the ink, along with 4 pounds of the best mineral lamp black, and 9½ pounds of good vegetable lamp black; then add the warm varnish by slow degrees, carefully stirring, to produce a perfect incorporation of all the ingredients. This mixture is next to be subjected to a mill, or slab and muller, till it be levigated into a smooth uniform paste.

One pound of a superfine printing ink may be made by the following recipe of Mr. Savage: — Balsam of capivi, 9 oz.; lamp black, 3 oz.; indigo and prussian blue, together, p. m. 1½ oz.; Indian red, ¼ oz.; turpentine (yellow) soap, dry, 3 oz. This mixture is to be ground upon a slab, with a muller, to an impalpable smoothness. The pigments used for coloured printing inks are, carmine, lakes, vermilion, red lead, Indian red, Venetian red, chrome yellow, chrome red or orange, burnt *terra di Sienna*, gall-stone, Roman ochre, yellow ochre, verdigris, blues and yellows mixed for greens, indigo, prussian blue, Antwerp blue, lustra, umber, sepia, browns mixed with Venetian red, &c.

PRINTING MACHINE. (*Typographie mécanique*, Fr.; *Druckmaschine*, Germ.) In reviewing those great eras of national industry, when the productive arts, after a long period of irksome vassalage, have suddenly achieved some new conquest over the inertia of matter, the contemplative mind cannot fail to be struck with the insignificant part which the academical philosopher has generally played in such memorable events.

Engrossed with barren syllogisms, or equational theorems, often little better than truisms in disguise, he nevertheless believes in the perfection of his attainments, and disdains to soil his hands with those handicraft operations at which all improvements in the arts must necessarily begin. He does not deem a manufacture worthy of his regard, till it has worked out its own grandeur and independence with patient labour and consummate skill. In this spirit the men of speculative science neglected for 60 years the steam engine of Newcomen, till the artisan Watt transformed it into an automatic prodigy; they have never deigned to illustrate by dynamical investigations the factory mechanisms

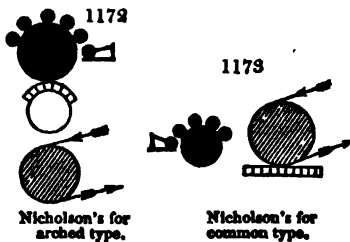
of Arkwright, yet nothing in the whole compass of art deserves it so well; and though perfectly aware that revolvency is the leading law in the system of the universe, they have never thought of showing the workman that this was also the true principle of every automatic machine.

These remarks seem to be peculiarly applicable to book-printing, an art invented for the honour of learning and the glory of the learned, though they have done nothing for its advancement; yet by the overruling bounty of Providence it has eventually served as the great teacher and guardian of the whole family of man.

It has been justly observed by Mr. Cowper, in his ingenious lecture,* that no improvement had been introduced in this important art, from its invention till the year 1798, a period of nearly 350 years. In Dr. Dibdin's interesting account of printing, in the *Bibliographical Decameron*, may be seen representations of the early printing-presses, which exactly resemble the wooden presses in use a few years back. A new era has, however, now arrived, when the demands for prompt circulation of political intelligence require powers of printing newspapers beyond the reach of the most expeditious hand presswork.

For the first essential modification of the old press, the world is indebted to the late Earl Stanhope. † His press is formed of iron, without any wood; the table upon which the form of types is laid, as well as the platen or surface which immediately gives the impression, is of cast iron, made perfectly level; the platen being large enough to print a whole sheet at one pull. The compression is applied by a beautiful combination of levers, which give motion to the screw, cause the platen to descend with progressively increasing force till it reaches the type, when the power approaches the maximum; upon the infinite lever principle, the power being applied to straighten an obtuse-angled jointed lever. This press, however, like all its flat-faced predecessors, does not act by a continuous, but a reciprocating motion, and can hardly be made automatic; nor does it much exceed the old presses in productiveness, since it can turn off only 250 impressions per hour.

The first person who publicly projected a self-acting printing-press, was Mr. William Nicholson, the able editor of the *Philosophical Journal*, who obtained a patent in 1790-1, for imposing types upon a cylindrical surface; this disposition of types, plates, and blocks, being a new invention (see *fig. 1172.*); 2, for applying the ink upon the surface of the types, &c., by causing the surface of a cylinder smeared with the colouring-matter to roll over them; or else causing the types to apply themselves to the said cylinder. For the purpose of spreading the ink evenly over this cylinder, he



proposed to apply three or more distributing rollers longitudinally against the inking cylinder, so that they might be turned by the motion of the latter. 3. "I perform," he says, "*all my impressions by the action of a cylinder, or cylindrical surface; that is, I cause the paper to pass between two cylinders, one of which has the form of types attached to it, and forming part of its surface; and the other is faced with cloth, and serves to press the paper so as to take off an impression of the colour previously applied; or otherwise I cause the form of types, previously coloured, to pass in close and successive contact with the paper wrapped round a cylinder with woollen.*" (See *Figs. 1172. and 1173.*) ‡

In this description Mr. Nicholson indicates pretty plainly the principal parts of modern printing machines; and had he paid the same attention to any one part of his invention which he fruitlessly bestowed upon attempts to attach types to a cylinder, or had he bethought himself of curving stereotype plates, which were then beginning to be talked of, he would in all probability have realized a working apparatus, instead of scheming merely ideal plans.

The first operative printing machine was undoubtedly contrived by, and constructed under the direction of, M. König, a clockmaker from Saxony, who, so early as the year 1804, was occupied in improving printing-presses. Having failed to interest the continental printers in his views, he came to London soon after that period, and submitted his plans to Mr. T. Bensley, our celebrated printer, and to Mr. R. Taylor, late one of the editors of the *Philosophical Magazine*.

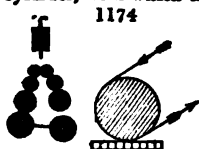
* On the recent improvements in printing, first delivered at the Royal Institution, February 22, 1838.

† Lord Stanhope is the only man of learning whose name figures in the annals of typography.

‡ The black parts in these little diagrams, 1172-31, indicate the inking apparatus; the diagonal lines, the cylinders upon which the paper to be printed is applied; the perpendicular lines, the plates or types; and the arrows show the track pursued by the sheet of paper.

These gentlemen afforded Mr. König and his assistant Bauer, a German mechanic, liberal pecuniary support. In 1811, he obtained a patent for a method of working a common hand-press by power; but after much expense and labour he was glad to renounce the scheme. He then turned his mind to the use of a cylinder for communicating the pressure, instead of a flat plate; and he finally succeeded, sometime before the 28th November 1814, in completing his printing automaton; for on that day the editors of the Times informed their readers that they were perusing for the first time a newspaper printed by steam-impelled machinery; it is a day, therefore, which will be ever memorable in the annals of typography.

In that machine the form of type was made to traverse horizontally under the pressure cylinder, with which the sheet of paper was held in close embrace by means of a series

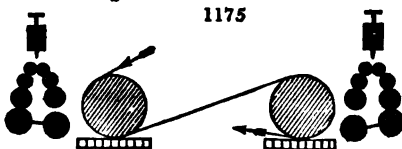


1174
König's single, for one side of the sheet.

of endless tapes. The ink was placed in a cylindrical box, from which it was extruded by means of a powerful screw, depressing a well-fitted piston; it then fell between two iron rollers, and was by their rotation transferred to several other subjacent rollers, which had not only a motion round their axes, but an alternating traverse motion (endwise). This system of equalizing rollers terminated in two which applied the ink to the types. (See *fig.* 1174. This plan of inking evidently involved a rather complex mechanism, was hence difficult to manage, and sometimes required two hours to get into good working trim. It has been superseded by a happy invention of Mr. Cowper, to be presently described.

In order to obtain a great many impressions rapidly from the same form, a paper-conducting cylinder (one embraced by the paper) was mounted upon each side of the inking apparatus, the form being made to traverse under both of them. This double-action machine threw off 1100 impressions per hour when first finished; and by a subsequent improvement, no less than 1800.

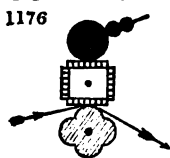
Mr. König's next feat was the construction of a machine for printing both sides of



1175
König's double, for both sides of the sheet.

the newspaper at each complete traverse of the forms. This resembled two single machines, placed with their cylinders towards each other, at a distance of two or three feet; the sheet was conveyed from one paper cylinder to another, as before, by means of tapes; the track of the sheet exactly resembled the letter S laid horizontally, thus, *co*; and the sheet was turned over or reversed in the course of its passage. At the first paper cylinder it received the impression from the first form, and at the second it received it from the second form; whereby the machine could print 750 sheets of book letter-press on both sides in an hour. This new register apparatus was erected for Mr. T. Bensley, in the year 1815, being the only machine made by Mr. König for printing upon both sides. See *fig.* 1175.

Messrs. Donkin and Bacon had for some years previous to this date been busily engaged with printing machines, and had indeed, in 1813, obtained a patent for an



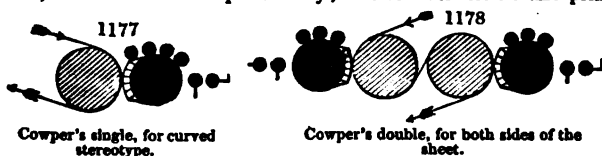
1176
Donkin and Bacon's for type.

apparatus, in which the types were placed upon the sides of a revolving prism; the ink was applied by a roller, which rose and fell with the eccentricities of the prismatic surface, and the sheet was wrapped upon another prism fashioned so as to coincide with the eccentricities of the type prism. One such machine was erected for the University of Cambridge. (See *fig.* 1176.) It was a beautiful specimen of ingenious contrivance and good workmanship. Though it was found to be too complicated for common operatives, and defective in the mechanism of the inking process; yet it exhibited for the first time the elastic inking rollers, composed of glue combined with treacle, which alone constitute one of the finest inventions of modern typography. In König's machine the rollers were of metal covered with leather, and never answered their purpose very well.

Before proceeding further, I may state that the above elastic composition, which resembles caoutchouc not a little, but is not so firm, is made by dissolving with heat, in two pounds of ordinary treacle, one pound of good glue, previously soaked during a night in cold water.

In the year 1815, Mr. Cowper turned his scientific and inventive mind to the subject of printing machines, and has since, in co-operation with his partner, Mr. Applegath, carried them to an unlooked-for degree of perfection. In 1815 Mr. Cowper obtained a patent for curving stereotype plates, for the purpose of fixing them on a cylinder.

Several machines so mounted, capable of printing 1000 sheets per hour upon both sides, are at work at the present day; twelve machines on this principle having been



made for the Directors of the Bank of England a short time previous to their re-issuing gold. See *figs.* 1177. and 1178.

It deserves to be remarked here, that the same object seems to have occupied the attention of Nicholson, Donkin, Bacon, and Cowper; viz., the revolution, of the form of types. Nicholson sought to effect this by giving to the shank of a type a shape like the stone of an arch; Donkin and Bacon by attaching types to the sides of a revolving prism; and Cowper, more successfully, by curving a stereotype plate. (See *fig.* 1177.) In these machines Mr. Cowper places two paper cylinders side by side, and against each of them a cylinder for holding the plates; each of these four cylinders is about two feet in diameter. Upon the surface of the stereotype-plate cylinder, four or five inking rollers of about three inches in diameter are placed; they are kept in their position by a frame at each end of the said cylinder, and the axes of the rollers rest in vertical slots of the frame, whereby having perfect freedom of motion, they act by their gravity alone, and require no adjustment.

The frame which supports the inking rollers, called the waving-frame, is attached by hinges to the general framework of the machine; the edge of the stereotype-plate cylinder is indented, and rubs against the waving-frame, causing it to vibrate to and fro, and consequently to carry the inking rollers with it, so as to give them an unceasing traverse movement. These rollers distribute the ink over three-fourths of the surface of the cylinder, the other quarter being occupied by the curved stereotype plates. The ink is contained in a trough, which stands parallel to the said cylinder, and is formed by a metal roller revolving against the edge of a plate of iron; in its revolution it gets covered with a thin film of ink, which is conveyed to the plate-cylinder by a distributing roller vibrating between both. The ink is diffused upon the plate cylinder as before described; the plates in passing under the inking rollers become charged with the coloured varnish; and as the cylinder continues to revolve, the plates come into contact with a sheet of paper on the first paper cylinder, which is then carried by means of tapes to the second paper cylinder, where it receives an impression upon its opposite side from the plates upon the second cylinder.

Thus the printing of the sheet is completed. Though the above machine be applicable only to stereotype plates, it has been of general importance, because it formed the foundation of the future success of Messrs. Cowper and Applegath's printing machinery, by showing them the best method of serving out, distributing, and applying the coloured varnish to the types.

In order to adapt this method of inking to a flat type-form machine, it was merely requisite to do the same thing upon an extended flat surface or table, which had been performed upon an extended cylindrical surface. Accordingly, Messrs. Cowper and Applegath constructed a machine for printing both sides of the sheet from type, including the inking apparatus, and the mode of conveying the sheet from the one paper cylinder to the other, by means of drums and tapes. It is highly creditable to the scientific judgment of these patentees, that in new modelling the printing machine, they dispensed with forty wheels, which existed in Mr. König's apparatus, when Mr. Bensley requested them to apply their improvements to it.

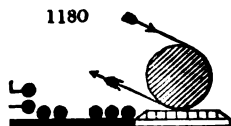
The distinctive advantages of these machines, and which have not hitherto been equalled, are the uniform distribution of the ink, the equality as well as delicacy with which it is laid upon the types, the diminution in its expenditure, amounting to one half upon a given quantity of letter-press, and the facility with which the whole mechanism is managed. The band inking-roller, and distributing-table, now so common in every printing-office in Europe and America, is the invention of Mr. Cowper, and was specified in his patent. The vast superiority of the inking apparatus in his machines, over the balls used of old, induced him to apply it forthwith to the common press, and most successfully for the public; but with little or no profit to the inventor, as the plan was unceremoniously infringed throughout the kingdom, by such a multitude of printers, whether rich or poor, as to render all attempts at reclaiming his rights by prosecution hopeless. See *fig.* 1179.

To construct a printing machine which shall throw off two sides at a time with exact register, that is, with the second side placed precisely upon the back of the

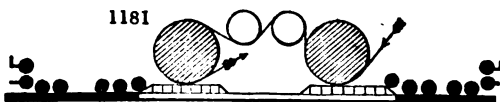


1179
Cowper's inking table and roller.

first, is a very difficult problem, which was first practically solved by Messrs. Applegath and Cowper. It is comparatively easy to make a machine which shall print the one side of a sheet of paper first, and then the other side, by the removal of one form, and the introduction of another; and thus far did Mr. König advance. A correct register requires the sheet, after it has received its first impression from one cylinder, to travel



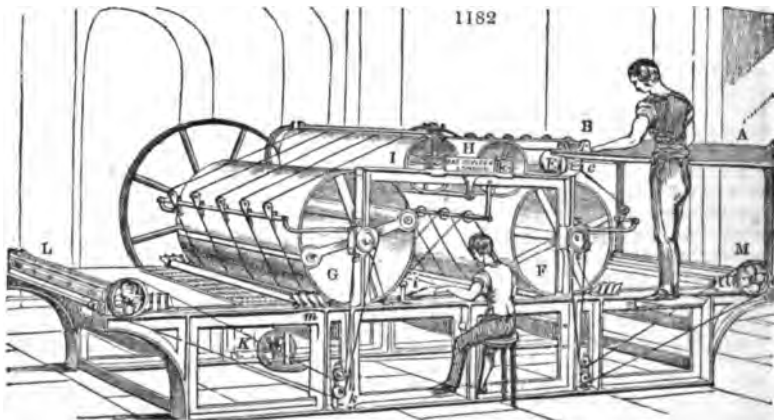
Applegath and Cowper's single.



Applegath and Cowper's double

round the peripheries of the cylinders and drums, at such a rate as to meet the types of the second side at the exact point which will ensure this side falling off nearly geometrical nicety upon the back of the first. For this purpose, the cylinders and drums must revolve at the very same speed as the carriage underneath; hence the least incorrectness in the workmanship will produce such defective typography as will not be endured in book-printing at the present day, though it may be tolerated in newspapers. An equable distribution of the ink is of no less importance to beautiful letter-press. See *figs.* 1180, 1181.

The machines represented in *figs.* 1183, 84, 85, are different forms of those which have been patented by Messrs. Applegath and Cowper. That shown in *figs.* 1182, 1184, prints both sides of the sheet during its passage, and is capable of throwing off nearly 1000 finished sheets per hour. The moistened quires of blank paper being piled upon a table A, the boy, who stands on the adjoining platform, takes up one sheet after another, and lays them upon the feeder B, which has several linen girths passing across its surface, and round a pulley at each end of the feeder; so that whenever the pulleys begin to revolve, the motion of the girths carries forward the sheet, and delivers it over the entering roller C, where it is embraced between two series of endless tapes, that pass round a series of tension rollers. These tapes are so placed as to fall partly between, and partly exterior to, the pages of the printing; whereby they remain in close contact with the sheet of paper on both of its sides during its progress through the machine. The paper is thus conducted from the first printing cylinder F, to the second cylinder G, without having the truth of its register impaired, so that the coincidence of the two pages is perfect. These two great cylinders, or drums, are made of cast iron, turned perfectly true upon a self-acting lathe;* they are clothed in these parts, corresponding to the typographic impression, with fine woollen cloth, called *blankets* by the pressmen, and revolve upon powerful shafts which rest in brass bearings of the strong framing of the

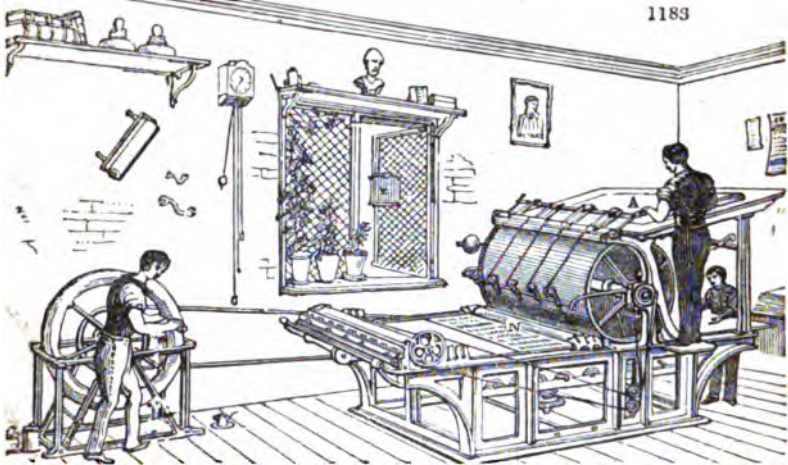


machine. These bearings, or plummer blocks, are susceptible of any degree of adjustment, by set screws. The drums H and I are made of wood; they serve to conduct the sheet evenly from the one printing cylinder to the other.

One series of tapes commences at the upper part of the entering drum E, proceeds in contact with the right-hand side and under surface of the printing cylinder F, passes

* I have witnessed with much pleasure the turning of these great cylinders in Messrs. Cowper's factory at Manchester.

next over the carrier-drum *m*, and under the carrier-drum *i*; then encompassing the left-hand side and under portion of the printing drum *o*, it passes in contact with the

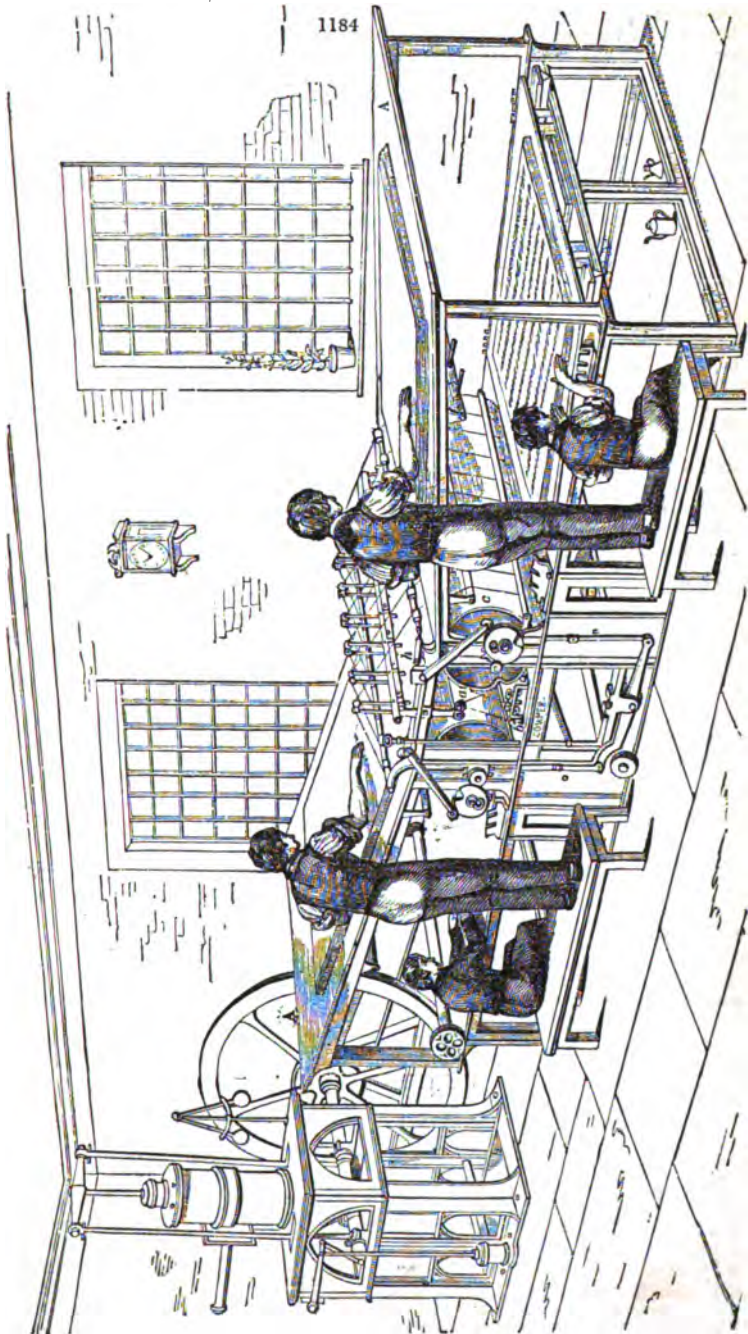


small tension rollers *a, b, c, d*, *fig. 1184.*, and finally arrives at the roller *z*, which may be called the commencement of the one series of endless tapes. The other series may be supposed to commence at the roller *h*; it has an equal number of tapes, and corresponds with the former in being placed upon the cylinders so that the sheets of paper may be held securely between them. This second series descends from the roller *h*, *fig. 1184.*, to the entering drum *z*, where it meets and coincides with the first series in such a way that both sets of tapes proceed together under the printing cylinder *r*, over *n*, under *l*, and round *o*, until they arrive at the roller *i*, *fig. 1182.*, where they separate, after having continued in contact, except at the places where the sheets of paper are held between them. The tapes descend from the roller *i*, to a roller at *k*, and, after passing in contact with rollers at *l, m, n*, they finally arrive at the roller *h*, where they were supposed to commence. Hence two series of tapes act invariably in contact, without the least mutual interference, as may be seen by inspection of the *Figs. 1182, 1183, 1184.*

The various cylinders and drums revolve very truly by means of a system of toothed wheels and pinions mounted at their ends. Two horizontal forms of types are laid at a certain distance apart upon the long carriage *m*, adjoining to each of which there is a flat metallic plate, or inking table, in the same plane. The common carriage, bearing its two forms of type and two inking tables, is moved backwards and forwards, from one end of the printing machine to the other, upon rollers attached to the frame-work, and in its traverse brings the types into contact with the sheet of paper clasped by the tapes round the surfaces of the printing cylinders. This alternate movement of the carriage is produced by a pinion working alternately into the opposite sides of a rack under the table. The pinion is driven by the bevel wheels *x*.

The mechanism for supplying the ink, and distributing it over the forms, is one of the most ingenious and valuable inventions belonging to this incomparable machine, and is so nicely adjusted, that a single grain of the pigment may suffice for printing one side of a sheet. Two similar sets of inking apparatus are provided; one at each end of the machine, adapted to ink its own form of type. The metal roller *z*, called the *ductor* roller, as it draws out the supply of ink, has a slow rotatory motion communicated to it by a catgut cord, which passes round a small pulley upon the end of the shaft of the printing cylinder *o*. A horizontal plate of metal, with a straight-ground edge, is adjusted by set screws, so as to stand nearly in contact with the ductor roller. This plate has an upright ledge behind, converting it into a sort of trough or magazine, ready to impart a coating of ink to the roller, as it revolves over the table. Another roller, covered with elastic composition (see *supra*), called the vibrating roller, is made to travel between the ductor roller and the inking table; the vibrating roller, as it rises, touches the ductor roller for an instant, abstracts a film of ink from it, and then descends to transfer it to the table. There are 3 or 4 small rollers of distribution, placed somewhat diagonally across the table at *m*, (inclined only 2 inches from a parallel to the end of the frame,) furnished with long slender axles, resting in vertical slots, whereby they are left at liberty to revolve and to traverse at the same time; by which compound movement they are enabled to efface all inequality in the surface of the varnish, or to effect a per-

fect distribution of the ink along the table. The table thus evenly smeared, being made to pass under the 3 or 4 proper inking rollers *x*, *fig. 1183*, imparts to them an uniform



film of ink, to be immediately transferred by them to the types. Hence each time that the forms make a complete traverse to and fro, which is requisite for the printing of every sheet, they are touched no less than eight times by the inking rollers. Both the distributing and inking rollers turn in slots, which permit them to rise and fall so as to bear with their whole weight upon the inking table and the form, whereby they never stand in need of any adjustment by screws, but are always ready for work when dropped into their respective places.

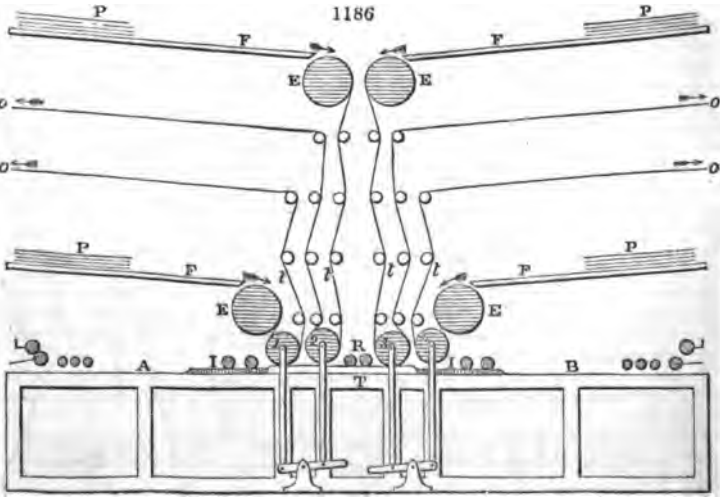
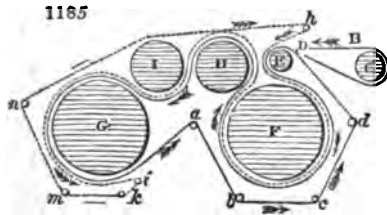
Motion is given to the whole system of apparatus by a strap from a steam engine going round a pulley placed at the end of the axle at the back of the frame; and one steam-horse power being adequate to drive two double printing machines; while a single machine may be driven by the power of two men acting upon a fly-wheel. In Messrs. Clowes' establishment, in Stamford-street, two five-horse engines actuate nineteen of the above described machines.

The operation of printing is performed as follows: — See *fig.* 1185.

The sheets being carefully laid, one by one, upon the linen girths, at the feeder *a*, the rollers *c* and *d* are made to move, by means of a segment wheel, through a portion of a revolution. This movement carries on the sheet of paper sufficiently to introduce it between the two series of endless tapes at the point where they meet each other upon the entering drum *x*. As soon as the sheet is fairly embraced between the tapes, the rollers *c* and *d* are drawn back, by the operation of a weight, to their original position, so as to be ready to introduce another sheet into the machine. The sheet, advancing between the endless tapes, applies itself to the blanket upon the printing cylinder *r*, and as it revolves meets the first form of types, and receives their impression; after being thus printed on one side, it is carried, over *u* and under *l*, to the blanket upon the printing cylinder *a*, where it is placed in an inverted position; the printed side being now in contact with the blanket, and the white side being outwards, meets the second form of types at the proper instant, so as to receive the second impression, and get completely printed. The perfect sheet, on arriving at the point *i*, where the two series of tapes separate, is tossed out by centrifugal force into the hands of a boy.

The diagram, *fig.* 1185, shows the arrangement of the tapes, agreeably to the preceding description; the feeder *a*, with the rollers *c* and *d*, is seen to have an independent endless girth.

The diagram, *fig.* 1186, explains the structure of the great machine contrived by Messrs. Applegath and Cowper for printing the *Times* newspaper. Here there are four places to lay on the sheets, and four to take them off; consequently, the assistance of eight lads is required. *P, P, P, P*, are the four feeding-boards; *x, x, x, x*, are the four entering drums, upon which the sheets are introduced between the tapes *t, t, t, t*, whence they are conducted to the



four printing cylinders, 1, 2, 3, 4; τ is the form of type; τ, τ , are two inking tables, of which one is placed at each end of the form. The inking apparatus is similar to that above described, with the addition of two central inking rollers α , which likewise receive their ink from the inking tables. The printing cylinders 1, 2, 3, 4, are made to rise and fall about half an inch; the first and third simultaneously, as also the second and fourth. The form of type, in passing from Λ to α , prints sheets at 1 and 3; in returning from α to Λ , it prints sheets at 4 and 2; while the cylinder alternately falls to give the impression, and rises to permit the form to pass untouched.

Each of the lines marked t , consists of two endless tapes, which run in contact in the parts shown, but separate at the entering drums α , and at the taking off parts o, o, o, o . The return of the tapes to the entering drum is omitted in the diagram, to avoid confusion of the lines.

The sheets of paper being laid upon their respective feeding-boards, with the fore edges just in contact with the entering drum, a small roller, called the drop-down roller, falls, at proper intervals, down upon the edges of the sheets; the drum and the roller being then removed, instantly carry on the sheet, between the tapes t , downwards to the printing cylinder, and thence upwards to o, o, o, o , where the tapes are parted, and the sheet falls into the hands of the attendant boy. This noble mechanism is so perfectly equipped, that it is generally in full work within four minutes after the form is brought into the machine-room. The speed of König's machine, by which the *Times* was formerly printed, was such as to turn out 1800 papers per hour; but the later improvement of Applegath and Cowper threw off at least 4200 per hour, and it is still used for printing the *Times* "Supplement."

This almost miraculous invention fully answered the purpose of the *Times* until the last few years, when the immense and still increasing demand upon its powers, rendered it necessary to provide a machine which could work off at least 10,000 copies of the paper per hour.

"In considering the means of solving this problem, it is necessary to observe, that whatever expedient may be used, the sheets of paper to be printed must be delivered one by one to the fingers of the machine by an attendant. After they once enter the machine they are carried through it and printed by self-acting machinery. But in the case of sheets so large as those of newspapers, it is found that they cannot be delivered with the necessary precision by manipulation at a more rapid rate than two in five seconds, or twenty-five per minute, being at the rate of 1500 sheets per hour. Now, in this manner, to print at the rate of 10,000 per hour, would require seven cylinders, to place which so as to be acted upon by a type form moving alternately in a horizontal frame, in the manner already described, would present mechanical difficulties almost insurmountable.

"In the face of these difficulties, Mr. Applegath, to whom the world is indebted for the invention of *The Times* printing machine, decided on abandoning the reciprocating motion of the type form, arranging the apparatus so as to render the motion continuous. This necessarily involved circular motion, and accordingly he resolved upon attaching the columns of type to the sides of a large drum or cylinder, placed with its axis vertical, instead of the horizontal frame which had been hitherto used. A large central drum is erected, capable of being turned round its axis. Upon the sides of this drum are placed vertically the columns of type. These columns, strictly speaking, form the sides of a polygon, the centre of which coincides with the axis of the drum, but the breadth of the columns is so small compared with the diameter of the drum, that their surfaces depart very little from the regular cylindrical form. On another part of this drum is fixed the inking table. The circumference of this drum in *The Times* printing machine measures 200 inches, and it is consequently 64 inches in diameter.

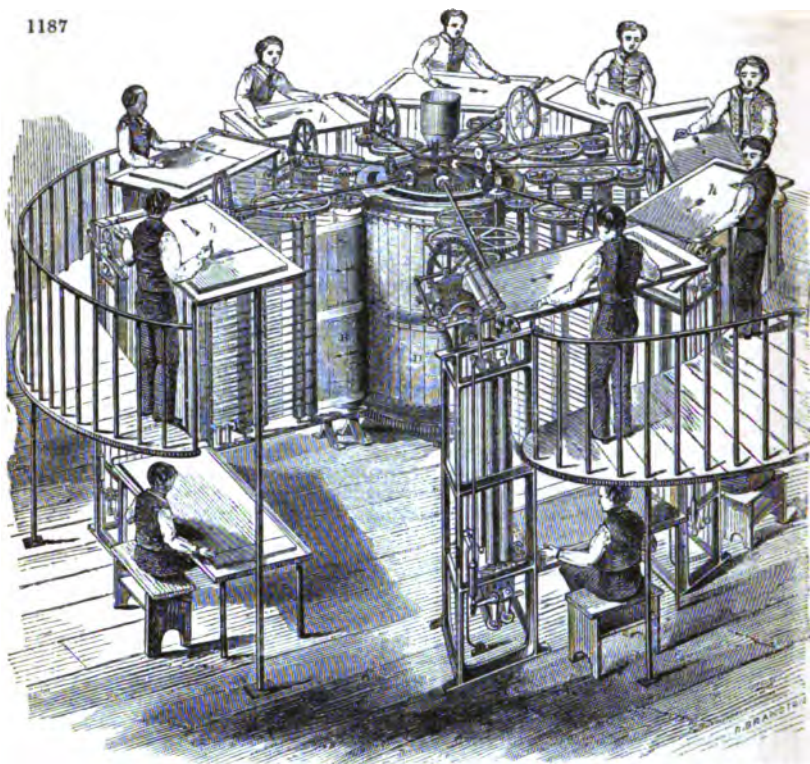
"The general form and arrangement of the machine are represented *fig. 1187*, where δ is the great central drum which carries the type and inking tables.

"This drum is surrounded by eight cylinders, α, α , &c., also placed with their axes vertical, upon which the paper is carried by tapes in the usual manner. Each of these cylinders is connected with the drum by toothed wheels, in such a manner that their surfaces respectively must necessarily move at exactly the same velocity as the surface of the drum. And if we imagine the drum thus in contact with these eight cylinders to be put in motion, and to make a complete revolution, the type form will be pressed successively against each of the eight cylinders, and if the type were previously inked, and each of the eight cylinders supplied with paper, eight sheets of paper would be printed in one revolution of the drum.

"It remains, therefore, to explain, first, how the type is eight times inked in each revolution; and, secondly, how each of the eight cylinders is supplied with paper to receive their impression.

"Beside the eight paper cylinders are placed eight sets of inking rollers; near these are placed two ductor rollers. These ductor rollers receive a coating of ink from reser-

1187



voirs placed above them. As the inking table attached to the revolving drum passes each of these ductor rollers, it receives from them a coating of ink. It next encounters the inking rollers to which it delivers over this coating. The types next, by the continued revolution of the drum, encounter these inking rollers, and receive from them a coating of ink, after which they meet the paper cylinders, upon which they are impressed, and the printing is completed.

"Thus in a single revolution of the great central drum the inking table receives a supply eight times successively from the ductor rollers, and delivers over that supply eight times successively to the inking rollers, which, in their turn, deliver it eight times successively to the faces of the type, from which it is conveyed finally to the eight sheets of paper held upon the eight cylinders by the tapes.

"Let us now explain how the eight cylinders are supplied with paper. Over each of them is erected a sloping desk, *A, A, &c.*, upon which a stock of unprinted paper is deposited. Beside this desk stands the "layer on," who pushes forward the paper, sheet by sheet, towards the fingers of the machine.

"These fingers, seizing upon it, first draw it down in a vertical direction between tapes in the eight vertical frames until its vertical edges correspond with the position of the form of type on the printing cylinder. Arrived at this position its vertical motion is stopped by a self-acting apparatus provided in the machine, and it begins to move horizontally, and it is thus carried towards the printing cylinder by the tapes. As it passes round this cylinder it is impressed upon the type, and printed. It is then carried back horizontally by similar tapes on the other side of the frame, until it arrives at another desk, where the "taker off" awaits it. The fingers of the machine are there disengaged from it, and the "taker off" receives it, and disposes it upon the desk. This movement goes on without interruption; the moment that one sheet descends from the hands of the "layer on," and being carried vertically downwards begins to move horizontally, space is left for another, which he immediately supplies, and in this manner he delivers to the machine at the average rate of two sheets every five seconds, and the same delivery taking

place at each of the eight cylinders, there are 16 sheets delivered and printed every five seconds.

"It is found that by this machine in ordinary work between 10,000 and 11,000 per hour can be printed; but with very expert men to deliver the sheets, a still greater speed can be attained. Indeed, the velocity is limited, not by any conditions affecting the machine, but by the power of the men to deliver the sheets to it.

"In case of any misdelivery a sheet is spoilt, and, consequently, the effective performance of the machine is impaired. If, however, a still greater speed of printing were required, the same description of machine, without changing its principle, would be sufficient for the exigency; it would be necessary that the types should be surrounded with a greater number of printing cylinders.

"The machine which was erected in the Exhibition, the property of Mr. Ingram, was used for printing the *Illustrated London News*. The great central cylinder was in this case surrounded by only four printing cylinders, each superintended by two men.

"It may be right to observe, that these surrounding cylinders and rollers, in the case of *The Times* machine, are not uniformly distributed round the great central drum; they are so arranged as to leave on one side of that drum an open space equal to the width of the type form. This is necessary in order to give access to the type form so as to adjust it.

"In a machine where the number of type cylinders is not so crowded round the drum, this precaution is not necessary.

"One of the practical difficulties which Mr. Applegath had to encounter in the solution of the problem, which he has so successfully effected, arose from the shock produced to the machinery by reversing the motion of the horizontal frame, which in the old machine carried the type form and inking table, a moving mass which weighed a ton! This frame had a motion of 88 inches in each direction, and it was found that such a weight could not be driven through such a space with safety at a greater rate than about 45 strokes per minute, which limited its *maximum* producing power to 5000 sheets per hour.

"Another difficulty in the construction of this vast piece of machinery, was so to regulate the self-acting mechanism that the impression of the type form should always be made in the centre of the page, and so that the space upon the paper occupied by the printed matter on one side may coincide exactly with that occupied by the printed matter on the other side.

"The type form fixed on the central drum moves at the rate of 70 inches per second, and the paper is moved in contact with it of course at exactly the same rate. Now, if by any error in the delivery or motion of a sheet of paper, it arrive at the printing cylinder 1-70th part of a second too soon or too late, the relative position of the columns will vary by 1-70th part of 70 inches — that is to say, by one inch. In that case the edge of the printed matter on one side would be an inch nearer to the edge of the paper than on the other side. This is an incident which rarely happens, but when it does, a sheet, of course, is spoilt. In fact, the waste from that cause is considerably less in the present vertical machine than in the former less powerful horizontal one.

"The vertical position of the inking rollers is more conducive to the goodness of the work — for the type and engraving are only touched on their extreme surface — than the horizontal machine, where the inking rollers act by gravity; also any dust shaken out of the paper, which formerly was deposited upon the inking rollers, now falls upon the floor.

"With this machine 50,000 impressions have been taken without stopping to brush the form or table.

"The principle of this vertical cylinder machine is capable of almost unlimited extension. Mr. Applegath offered the Royal Commission to make a machine for the Great Exhibition, which with no rate of motion more rapid than that of *The Times*, should print 40,000 sheets per hour, or above eleven sheets between two ticks of a common clock!"*

PRUSSIAN BLUE, and PRUSSIAN OF POTASH, are two important articles of chemical manufacture, which must be considered together. The first is called by English chemists, *Ferrocyanodide of iron*, the *Cyanure ferroso-ferrique* of Berzelius; *Eisenblausaures Eisenoxyd*, or *eisencyanür + eisencyanid*, Germ.; the second is called *Ferrocyanodide of potassium*, the *Cyanure ferroso-potassique* of Berzelius; *Eisencyanur-kalium*, *cyancien + cyankalium*, or *Blausaures Eisenoxydul-kali*, Germ.

Prussian blue (*Berliner-blau*, Germ.), is a chemical compound of iron and cyanogen. When organic matters abounding in nitrogen, as dried blood, horns, hair, skins, or hoofs of animals, are triturated along with potash in a strongly ignited iron pot a dark gray mass is obtained, that affords to water the liquor originally called *lividium san-*

* The Great Exhibition and London in 1851, reviewed by Dr. Lardner, &c. London, 1852.

guinis, or blood-lye, which, by evaporation, yields lemon-coloured crystals in large rectangular tables, bevelled at the edges. This salt is called in commerce, prussiate of potash, and has for its ultimate constituents, potassium, iron, oxygen, and hydrogen, (the latter two in such proportions as to form water), and the peculiar compound *Cyanogen*, the *blausstoff* of the Germans.

These crystals consist, in 100 parts, of potassium 27.02, iron 12.82, cyanogen 37.40, water 12.76; or, cyanide of potassium 61.96, cyanide of iron 25.28, and water 12.76. They may be represented also by the following composition: 44.58 of potassa, 38.82 of hydrocyanic or prussic acid, and 16.60 of oxide of iron, in 100 parts; but the first appears to be their true chemical constitution. Dry ferrocyanodide of potassium is a compound of one atom of cyanide of iron, $54 = (28 + 26)$, and 2 atoms of cyanide of potassium, $132 = (26 \times 2 + 40 \times 2)$; the sum being 186; hydrogen being 1.0 in the scale of equivalents. The crystals of prussiate of potash are nearly transparent, soft, of a sweetish saline and somewhat bitterish taste, soluble in 4 parts of water at 52° F., and in 1 part of boiling water, but insoluble in alcohol. They are permanent in the air at ordinary temperatures, but in a moderately warm stove-room they part with 12½ per cent. of water, without losing their form or coherence, and become thereby a white friable anhydrous ferrocyanodide of potassium, consisting of 42.44 potassium, 42.87 cyanogen, and 14.69 iron, in 100 parts.

This salt is an excellent reagent for distinguishing metals from each other, as the following TABLE of the precipitates which it throws down from their saline solutions will show:—

| Metallic solutions. | Colour of precipitate. |
|---------------------------------|--|
| Antimony - - - - - | white. |
| Bismuth - - - - - | white. |
| Cadmium - - - - - | white, a little yellowish. |
| Cerium (protoxide) - - - - - | white, soluble in acids. |
| Cobalt - - - - - | green, soon turning reddish-gray. |
| Copper (protoxide) - - - - - | white, changing to red. |
| Do. (peroxide) - - - - - | brown-red. |
| Iron (protoxide) - - - - - | white, rapidly turning blue. |
| Do. (peroxide) - - - - - | dark blue. |
| Lead - - - - - | white, with a yellowish cast. |
| Manganese (protoxide) - - - - - | white, turning quickly peach or blood red. |
| (deutoxide) - - - - - | greenish-gray. |
| Mercury (protoxide) - - - - - | white. |
| Do. (peroxide) - - - - - | white, turning blue. |
| Molybdenum - - - - - | dark brown. |
| Nickel (oxide) - - - - - | white, turning greenish. |
| Palladium (protoxide) - - - - - | green (gelatinous), |
| Silver - - - - - | white, turning brown in the light. |
| Tantalum - - - - - | yellow, dark burned colour. |
| Tin (protoxide) - - - - - | white, (gelatinous). |
| Do. (peroxide) - - - - - | yellow, do. |
| Uranium - - - - - | red-brown. |
| Zinc - - - - - | white. |

No precipitations ensue with solutions of the alkaline or earthy salts, except that of yttria, which is white; nor with those of gold, platinum, rhodium, iridium, osmium in concentrated solutions), tellurium, chromium, tungstenium. All the precipitates by the ferrocyanodide of iron are double compounds of cyanide of iron with cyanide of the metal thrown down, which is produced by the reciprocal decomposition of the cyanide of potassium and the peculiar metallic oxide present in the solution. The precipitate from the sulphate of copper has a fine brown colour, and has been used as a pigment; but it is somewhat transparent, and therefore does not cover well. The precipitate from the peroxide salts of iron is a very intense prussian blue, called on the continent, Paris blue. It may be regarded as a compound of prussiate of protoxide and prussiate of peroxide of iron; or as a double cyanide of the protoxide and peroxide of iron, as the denomination *cyanure ferroso-ferrique* denotes. In numbers, its composition may be therefore stated thus: prussic or hydrocyanic acid, 48.48; protoxide of iron, 20.73; peroxide of iron, 30.79; or cyanogen, 46.71; iron, 37.36; water, 15.98; which represent its constitution when it is formed by precipitation with the prussiate of potash or a salt of iron that contains no protoxide. If the iron be but partially peroxidised in the salt, it will afford a precipitate, at first pale blue, which turns dark blue in the air, consisting of a mixture of prussiate of protoxide and prussiate of peroxide. In fact, the white cyanide of iron (the prussiate of the pure protoxide), when exposed to the air in

a moist condition, becomes, as above stated, dark blue; yet the new combination formed in this case through absorption of oxygen, is essentially different from that resulting from the precipitation by the peroxide of iron, since it contains an excess of the peroxide in addition to the usual two cyanides of iron. It has been therefore called *basic prussian blue*, and, from its dissolving in pure water, *soluble prussian blue*.

Both kinds of prussian blue agree in being void of taste and smell, in attracting humidity from the air when they are artificially dried, and being decomposed at a heat above 348° F. The neutral or insoluble prussian blue is not affected by alcohol; the basic, when dissolved in water, is not precipitated by that liquid. Neither is acted upon by dilute acids; but they form with concentrated sulphuric acid a white pasty mass, from which they are again reproduced by the action of cold water. They are decomposed by strong sulphuric acid at a boiling heat, and by strong nitric acid at common temperatures; but they are hardly affected by the muriatic. They become green with chlorine, but resume their blue colour when treated with disoxidizing reagents. When prussian blue is digested in warm water along with potash, soda, or lime, peroxide of iron is separated, and a ferroproussiatic of potash, soda, or lime remains in solution. If the prussian blue has been previously purified by boiling in dilute muriatic acid, and washing with water, it will afford by this treatment a solution of ferrocyanide of potassium, from which by evaporation this salt may be obtained in its purest crystalline state. When the powdered prussian blue is diffused in boiling water, and digested with red oxide of mercury, it parts with all its oxide of iron, and forms a solution of bi-cyanide, improperly called prussiate of mercury; consisting of 79.33 mercury, and 20.67 cyanogen; or upon the hydrogen equivalent scale, of 200 mercury, and 52 = (26 × 2) cyanogen. When this salt is gently ignited, it affords gaseous cyanogen. Hydrocyanic or prussic acid, which consists of 1 atom of cyanogen = 26, + 1 of hydrogen = 1, is prepared by distilling the mercurial bi-cyanide in a glass retort with the saturating quantity of dilute muriatic acid. Prussic acid may also be obtained by precipitating the mercury by sulphuretted hydrogen gas from the solution of its cyanide; as also by distilling the ferrocyanide of potassium along with dilute sulphuric acid. Prussic acid is a very volatile light fluid, eminently poisonous, and is spontaneously decomposed by keeping, especially when somewhat concentrated.

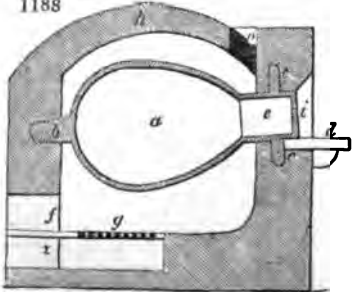
Having expounded the chemical constitution of prussian blue and prussiate of potash, I shall now treat of their *manufacture upon the commercial scale*.

1. *Of blood-lye*, the phlogisticated alkali of Scheele. Among the animal substances used for the preparation of this lixivium, blood deserves the preference, where it can be had cheap enough. It must be evaporated to perfect dryness, reduced to powder, and sifted. Hoofs, parings of horns, hides, old woollen rags, and other animal offals, are, however, generally had recourse to, as condensing most azotized matter in the smallest bulk. Dried funguses have been also prescribed. These animal matters may either be first carbonized in cast-iron cylinders, as for the manufacture of *sal ammoniac* (which see), and the residual charcoal may be then taken for making the ferroproussiatic; or the dry animal matters may be directly employed. The latter process is apt to be exceedingly offensive to the workmen and neighbourhood, from the nauseous vapours that are exhaled in it. Eight pounds of horn (hoofs), or ten pounds of dry blood, afford upon an average one pound of charcoal. This must be mixed well with good pearlash, (freed previously from most of the sulphate of potassa, with which it is always contaminated,) either in the dry way, or by soaking the bruised charcoal with a strong solution of the alkali; the proportion being one part of carbonate of potassa to from 1½ to 2 parts of charcoal, or to about eight parts of hard animal matter.

The pot for calcining the mixture of animal and alkaline matter is egg-shaped, as represented at *a*, *fig. 1188*, and is considerably narrowed at the neck *e*, to facilitate the closing of the mouth with a lid *i*. It is made of cast iron, about two inches thick in the

belly and bottom; this strength being requisite because the chemical action of the materials wears the metal fast away. It should be built into the furnace in a direction sloping downwards, (more than is shown in the figure,) and have a strong knob *b*, projecting from its bottom to support it upon the back wall, while its shoulder is embraced at the arms *c*, *e*, by the brickwork in front. The interior of the furnace is so formed as to leave but a space of a few inches round the pot, in order to make the flame play closely over its whole surface. The fire-door *f*, and the draught-hole *z*, of the ash-pit, are placed in the posterior part of the furnace, in order that the workmen may not be incommoded by the heat. The smoke vent *o*, issues through the

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The workmen may not be incommoded by the heat. The smoke vent *o*, issues through the

arched top *k* of the furnace, towards the front, and is thence led backwards by a flue to the main chimney of the factory. *d* is an iron or stone shelf, inserted before the mouth of the pot, to prevent loss in shovelling out the semi-liquid paste. The pot may be half filled with the materials.

The calcining process is different, according as the animal substances are fresh or carbonized. In the first case, the pot must remain open, to allow of diligent stirring of its contents, with a slightly bent flat iron bar or scoop, and of introducing more of the mixture as the intumescence subsides, during a period of five or six hours, till the nauseous vapours cease to rise, till the flame becomes smaller and brighter, and till a smell of ammonia be perceived. At this time, the heat should be increased, the mouth of the pot should be shut, and opened only once every half hour, for the purpose of working the mass with the iron paddle. When on opening the mouth of the pot, and stirring the pasty mixture, no more flame rises, the process is finished.

If the animal ingredients are employed in a carbonized state, the pot must be shut as soon as its contents are brought to ignition by a briskly urged fire, and opened for a few seconds only every quarter of an hour, during the action of stirring. At first, a body of flame bursts forth every time that the lid is removed; but by degrees this ceases, and the mixture soon agglomerates, and then softens into a paste. Though the fire be steadily kept up, the flame becomes less and less each time that the pot is opened; and when it ceases, the process is at an end. The operation, with a mass of 50 pounds of charcoal and 50 pounds of purified pearlash, lasts about 12 hours, the first time that the furnace is kindled; but when the pot has been previously brought to a state of ignition, it takes only 7 or 8 hours. In a well-appointed factory, the fire should be invariably maintained at the proper pitch, and the pots should be worked with relays of operatives.

The molten mass is now to be scooped out with an appropriate iron shovel, having a long shank, and caused to cool in small portions, as quickly as possible; but not by throwing it into water, as has sometimes been prescribed; for in this way a good deal of the cyanogen is converted into ammonia. If it be heaped up and kept hot in contact with air, some of the ferrocyanide is also decomposed, with diminution of the product. The crude mass is to be then put into a pan with cold water, dissolved by the application of a moderate heat, and filtered through cloths. The charcoal which remains upon the filter possesses the properties of decolouring syrups, vinegars, &c., and of destroying smells in a pre-eminent degree. It may also serve, when mixed with fresh animal coal, for another calcining operation.

As the iron requisite for the formation of the ferrocyanide is in general derived from the sides of the pot, this is apt to wear out into holes, especially at its under side, where the heat is greatest. In this event, it may be taken out of the furnace, patched up with iron-rust cement, and re-inserted with the sound side undermost. The erosion of the pot may be obviated in some measure by mixing iron borings or cinder (*hammerschlag*) with the other materials, to the amount of one or two hundredths of the potash.

The above lixivium is not a solution of pure ferroproussiate; it contains not a little cyanide of potassium, which in the course of the process had not absorbed the proper dose of iron to form a ferrocyanide; it contains also more or less carbonate of potash, with phosphate, sulphate, hydrogenated sulphuret, muriate, and sulpho-cyanide of the same base, as well as phosphate of lime; substances derived partly from the impure potash, and partly from the incinerated animal matters. Formerly that very complex impure solution was employed directly for the precipitation of prussian blue; but now, in all well regulated works, it is converted by evaporation and cooling into crystallized ferroproussiate of potash. The mother-water is again evaporated and crystallized, whereby a somewhat inferior ferroproussiate is obtained. Before evaporating the lye, however, it is advisable to add as much solution of green sulphate of iron to it, as will re-dissolve the white precipitate of cyanide of iron which first falls, and thereby convert the cyanide of potassium, which is present in the liquor, into ferrocyanide of potassium. The commercial proussiate of potash may be rendered chemically pure by making its crystals effloresce in a stove, fusing them with a gentle heat in a glass retort, dissolving the mass in water, neutralizing any carbonate and cyanide of potash that may be present with acetic acid, then precipitating the ferroproussiate of potash by the addition of a sufficient quantity of alcohol, and finally crystallizing the precipitated salt twice over in water. The sulphate of potash may be decomposed by acetate of baryta, and the resulting acetate of potash removed by alcohol.

2. *The precipitation of prussian blue.*—Green sulphate of iron is always employed by the manufacturer, on account of its cheapness, for mixing with solution of the ferroproussiate, in forming prussian blue, though the red sulphate, nitrate, or muriate of iron would afford a much richer blue pigment. Whatever salt of iron be preferred should be carefully freed from any cupreous impregnation, as this would give the pure blue a

dirty brownish cast. The green sulphate of iron is the most advantageous precipitant, on account of its affording protoxide, to convert into ferrocyanide any cyanide of potassium that may happen to be present in the uncrystallized lixivium. The carbonate of potash in that lixivium might be saturated with sulphuric acid before adding the solution of sulphate of iron; but it is more commonly done by adding a certain portion of alum; in which case, alumina falls along with the prussian blue; and though it renders it somewhat paler, yet it proportionally increases its weight; whilst the acid of the alum saturates the carbonate of potash, and prevents its throwing down iron-oxide, to degrade by its brown-red tint the tone of the blue. For every pound of pearlsh used in the calcination, from two to three pounds of alum are employed in the precipitation. When a rich blue is wished for, the free alkali in the prussian lye may be partly saturated with sulphuric acid, before adding the mingled solutions of copperas and alum. One part of the sulphate of iron is generally allowed for 15 or 20 parts of dried blood, and 2 or 3 of horn-shavings or hoofs. But the proportion will depend very much upon the manipulations; which, if skillfully conducted, will produce more of the cyanides of iron, and require more copperas to neutralize them. The mixed solutions of alum and copperas should be progressively added to the lye as long as they produce any precipitate. This is not at first a fine blue, but a greenish gray in consequence of the admixture of some white cyanide of iron; it becomes gradually blue by the absorption of oxygen from the air, which is favoured by agitation of the liquor. Whenever the colour seems to be as beautiful as it is likely to become, the liquor is to be run off by a spigot or cock from the bottom of the precipitation vats, into flat cisterns, to settle. The clear supernatant fluid, which is chiefly a solution of sulphate of potash, is then drawn off by a syphon; more water is run on with agitation to wash it, which after settling is again drawn off; and whenever the washings become tasteless, the sediment is thrown upon filter sieves, and exposed to dry, first in the air of a stove, but finally upon slabs of chalk or Paris plaster. But for several purposes, prussian blue may be best employed in the fresh pasty state, as it then spreads more evenly over paper and other surfaces.

A good article is known by the following tests: it feels light in the hand, adheres to the tongue, has a dark lively blue colour, and gives a smooth deep trace; it should not effervesce with acids, as when adulterated with chalk; nor become pasty with boiling water, as when adulterated with starch. The Paris blue, prepared without alum, with a peroxide salt of iron, displays, when rubbed, a copper-red lustre, like indigo. Prussian blue, degraded in its colour by an admixture of free oxide of iron, may be improved by digestion in dilute sulphuric or muriatic acid, washing, and drying. Its relative richness in the real ferroproussiate of iron may be estimated by the quantity of potash or soda which a given quantity of it requires to destroy its blue colour.

Sulphuretted hydrogen passed through prussian blue diffused in water, whitens it; while prussic acid is eliminated, sulphur is thrown down, and the sesquicyanide of iron is converted into the single cyanide. Iron and tin operate in the same way. When prussian blue is made with two atoms of ferrocyanide of potassium, instead of one, it becomes soluble in water.

For the mode of applying this pigment in dyeing, see CALICO-PRINTING.

Sesquiferrocyanate of potash, is prepared by passing chlorine gas through a solution of ferrocyanide of potassium, till it becomes red, and ceases to precipitate the peroxide salts of iron. The liquor yields, by evaporation, prismatic crystals, of a ruby-red transparency. They are soluble in 38 parts of water, and consist of 40.42 parts of sesquicyanide of iron, and 59.58 of cyanide of potassium. The solution of this salt precipitates the following metals, as stated in the table:—

| | | | |
|-----------------------|-----------------|----------------------|----------------|
| Bismuth - - - | pale yellow. | Mercury (peroxide) - | yellow. |
| Cadmium - - - | yellow. | Molybdenum - - - | red-brown. |
| Cobalt - - - | dark brown-red. | Nickel - - - | yellow-green. |
| Copper (protoxide) | red-brown. | Silver - - - | red-brown. |
| Do. (peroxide) - | yellow-green. | Tin (protoxide) - | white. |
| Iron, protoxide salts | of blue. | Uranium - - - | red-brown. |
| Manganese - - - | brown. | Zinc - - - | orange-yellow. |
| Mercury (protoxide) | red-brown. | | |

New process for prussian blue, which deserves peculiar notice, as the first in which interesting compound has been made to any extent independently of animal matter. Mr. Lewis Thompson received a well-merited medal from the Society of Arts, in 1837, for this invention. He justly observed that in the common way of manufacturing prussiate of potash, the quantity of nitrogen furnished by a given weight of animal matter is not large, and seldom exceeds 8 per cent.; and of this small quantity, at least one half appears to be dissipated during the ignition. It occurred to him that the atmosphere might be economically made to supply the requisite nitrogen, if caused to act in favourable circumstances upon a mixture of carbon and potash. He found the

following prescription to answer. Take of pearlash and coke, each 9 parts; iron turnings, 1 part; grind them together into a coarse powder; place this in an open crucible, and expose the whole for half an hour to a full red heat in an open fire, with occasional stirring of the mixture. During this process, little jets of purple flame will be observed to rise from the surface of the materials. When these cease, the crucible must be removed and allowed to cool. The mass is to be lixiviated; the lixivium, which is a solution of ferrocyanide of potassium, with excess of potash, is to be treated in the usual way, and the black matter set aside for a fresh operation, with a fresh dose of pearlash. Mr. Thompson states that one pound of pearlash, containing 45 per cent. of alkali, yielded 1355 grains of pure Prussian blue, or ferrocyanide of iron; or about 3 ounces avoirdupois.

PRUSSIATE OF POTASH. Leuch's *Polytechnic Zeitung*, June, 1837. Manufacture of Kalium Eisen Cyanure, by Hoffmayer and Prükner. — The Potash must be free from sulphate, for each atom of sulphur destroys an atom of the Eisencyanalkium. A very strong heat is advantageous. The addition of from 1 to 3 per cent. of saltpetre is useful, when the mass is too long of fusing. A reverberatory furnace (flammöfen) is recommended; but the flame must not beat too much upon the materials for fear of oxygenating them. When the smoky red flame ceases, it is useful to throw in from time to time small portions of uncarbonised animal matter, particularly where the flame first beats upon the mass, whereby the resulting gases prevent oxidation by the air. The animal matters should not be too much carbonised, but left somewhat brown coloured, provided they be readily pulverised. Of uncarbonised animal matters, the proportions may be 100 parts dried blood, to from 28 to 30 of potash (carbonate), and from 2 to 4 of hammerschlag (smithy scales), or iron filings. 2d. 100 parts of horns or hoofs; from 33 to 35 potash; 2 to 4 iron. 3d. 100 leather, 45 to 48 potash; and 2 to 4 iron. From blood, 8 to 9 per cent. of the prussiate are obtained; from horns, 9 to 10; and from leather, 5 to 6. The potash should be mixed in coarse particles, like peas, with the carbonised animal matter, which may be best done in a revolving pot, containing cannon-balls. Of the animal coal and potash, equal parts may be taken, except with that from leather, which requires a few more parts potash per cent. On the average, blood and horn coal should afford never less than 20 per cent. of prussiate, nor the leather than 8; but by good treatment, they may be made to yield, the first 25, and the last from 10 to 11.

Berry's patent process. — Reduce charcoal into bits of the size of a walnut, soak them with a solution of carbonate of potash in urine; and then pour over them a solution of nitrate or acetate of iron; dry the whole by a moderate heat and introduce them into the cast-iron tubes, presently to be described. The following proportions of constituents have been found to answer: — Ordinary potash, 30 parts; nitre, 10; acetate of iron, 15; charcoal or coke, 45 to 55; dried blood, 50. The materials, mixed and dried, are put into retorts similar to those for coal gas. The animal matter, however (the blood), is placed in separate compartments of pipes connected with the above retorts. The pipes containing the animal matter should be brought to a red heat before any fire is placed under the retorts.

In *fig. 1189*, A B C D, is a horizontal section of a furnace constructed to receive four elliptical iron pipes. The furnace is arched in the part A C B, in order to reverberate the heat, and drive it back on the pipes w, w', w'', w'''. These pipes are placed on the plane x r, of the ellipsoid. a a, represents the grating or bars of the furnace to be heated with coal or coke; 1 1, is the pot or retort shown in *figs. 1190, 1191, 1192*.

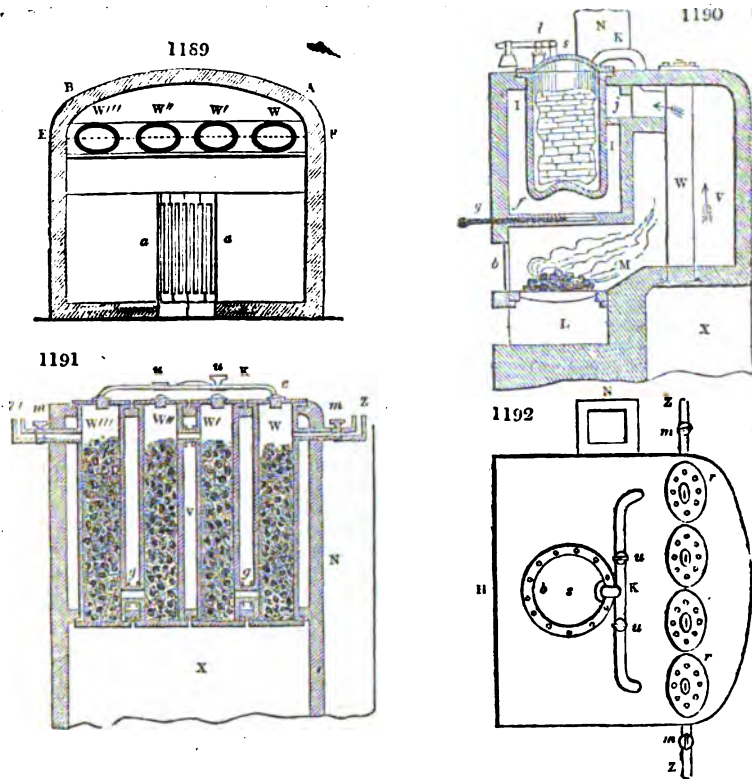
This pot or retort is placed in a separate compartment, as seen in *fig. 1189*, which is a vertical section, taken through *fig. 1192*, at the line a, b. x, is a connecting tube, from the retort and the elliptical pipes w.

In the section, *fig. 1190*, the shape of the tube x will be better seen; also its cocks s, and likewise its connection with the pipes w. l, is a safety valve; s, the cover of the pot or retort; L, is the ash-pit; and b, the door of the furnace; x, is an open space, roofed over, or a kind of shed, close to the furnace, and under it the pipes are emptied.

The arrows indicate the direction of the current of heat. This current traverses the intervals left between the pipes, and ascends behind them, passing through the aperture j, in the brickwork, which is provided with a valve or damper, for closing it, as required. The heat passes through this aperture, and strikes against the sides of the pot when the valve is open. Another valve f, g, must also be open to expose the pot or retort to the direct action of the fire. The smoke escapes by a lateral passage into a chimney x.

It must be remarked, that there is a direct communication between the chimney and that compartment of the furnace which contains the pipes, so that the heat, reflected from the part v, strikes on the pot or retort only when the pipes w, w', w'', w''', are sufficiently heated.

In *fig. 1191*, is shown an inclined plane x (also represented in *fig. 1190*.) and the junc-



tion-tubes which connect the four pipes with their gas-burners z, z, and the cocks m, m'. r, r, are covers, closing the pipes, and having holes formed in them; these holes are shut by the stoppers e.

Whether the pipes are placed in the vertical or horizontal position, it is always proper to be able to change the direction of the current of gas; this is easily done by closing, during one hour (if the operation is to last two hours,) the cocks u, m', and opening those u', m; then the gas passes through u', into the branch x, and entering w''', passes through q, into w'', through p, into w', and through o, and w, and finally escapes by the burner z. During the following or other hour, the cocks u', m, must be closed; the cocks u, m', being opened, the current then goes from u, into x, w, w', w'', w''', and escapes by the burner z', where it may be ignited.

The changing of the direction of the current dispenses, to a certain degree, with the labour required for stirring with a spatula the matters contained in the pipes; nevertheless, it is necessary, from time to time, to pass an iron rod or poker amongst the substances contained in the pipes. It is for this purpose that apertures are formed, so as to be easily opened and closed.

The patentee remarks, that although this operation is only described with reference to potash, for obtaining prussiate of potash, it is evident that the same process is applicable to soda; and when the above-mentioned ingredients are employed, soda being substituted for potash, the result will be prussiate of soda. — *Newton's Journal*, C. S. XXI. 96.

Manufacture of Prussiate of Potash. All things considered, the manufacture of prussiate of potash is, perhaps, less understood, and therefore less perfect, than that of any other chemical substance of equal importance. The conditions requisite to ensure success are totally unknown amongst scientific men, and the manufacturers themselves seem so divided in their opinions respecting the best modes of production, that nothing valuable can be deduced from the discordant results of their experience. Thus, whilst some are so careful to avoid the presence of water in the materials they employ, that these are highly dried before being cast into the furnace pot, others pay no regard at all

to this circumstance, or even actually wet the nitrogenised substances, with a view to increase their power. The difference in theory between these methods is so enormous, that it ought, long ago, to have shown itself in the practical results, if there be not some error in the assertion that prussiate of potash is entirely destroyed by steam at a red heat. That such is the case when pure prussiate is thus acted on, no one can doubt for a moment; but how far this is true with respect to the mixture of carbonaceous and alkaline matters contained in the furnace pot of a prussiate manufacturer, remains still to be investigated. Whatever be the plan adopted, a prodigious waste invariably occurs in making prussiate of potash; and fully two-thirds of all the nitrogen, existing in the azotised ingredients of the process, are driven off and lost. More frequently, indeed, the loss amounts to three-fourths, and even this is sometimes exceeded. The state of the weather, and the temperature of the furnace, also largely affect the production of prussiate of potash, — for damp, foggy weather, and a low, dull heat, are extremely prejudicial. The most favourable indications are, a heat verging on whiteness, and the production of a clear, bright flame, the moment the materials are thrown into the pot.

Woollen rags or clippings, and good American potash or pearlash, with an admixture of scrap iron, have given a larger produce than any other substances within the range of our experience, though, even in this instance, two-thirds of the whole nitrogen passed away as ammonia. In general, 1 ton of dried blood, or woollen rags, with about 3 cwts. of good potash, will produce from 2 cwts. to 2½ cwts. of prussiate of potash, and a proportionate amount of sulphate of potash. The presence of scrap iron in a proper state of subdivision is, however, necessary to insure the above result; for when no more is supplied than that which arises accidentally from the iron pot in which the operation is carried on, scarcely half these proportions will be obtained. A very useful mixture may be made of 1 ton of proper nitrogenised matter in a dry condition, with from 3 to 4 cwts. of pearlash in powder, and 50 or 60 lbs. of scrap iron in the form of wire, or thin sheets or clippings. This is to be projected by degrees into a thick iron pot previously brought to a bright cherry-red heat; and, after each addition, the whole contents of the pot must be well stirred with a heavy iron poker or bar, until the residue becomes pasty; when more of the mixture must be thrown in and similarly treated, until the pot is about half full; after this, the heat may be maintained for 15 or 20 minutes; and then the charge must be ladled out to make room for another operation. The form and nature of the iron pot are by no means matters of indifference. The form should be such as to prevent the access of air as much as possible, without causing unnecessary labour to the workman in the charging and emptying of the pot; and, in consequence of the high temperature employed, the cast-iron should be of the kind called "cold-blast iron;" for this will resist a much greater application of fire than "hot-blast iron." The old shape of a prussiate of potash pot is almost exactly that of an egg, with its upper part cut off; and this, in an economical point of view, is scarcely susceptible of improvement; but the pasty mass, after each operation, can be removed from this pot with great difficulty only; and the mixing or stirring is still more open to objection. Nevertheless, many manufacturers continue to employ this form. More recently, a kind of oblong shallow trough has come into use, which presents every facility for charging and discharging; but the waste of nitrogen is said to be considerable, and the wear and tear excessive; so that a middle shape, or combination of the two, appears indicated. We have, however, witnessed the employment of common gas-retorts for this purpose, and with the most unqualified success. In these, the action of the air is entirely prevented, and the stirring process goes on through an opening in the cover, which, being provided with a plug or stopper, permits the occasional condensation of much of the waste ammonia to take place; or, by the use of what are called "reciprocating retorts," enables the manufacturer to pass the volatile matters, arising from a recent charge, over the incandescent materials of an old or spent charge, so as to convert the ammonia they contain into cyanogen.

The first steps of the operation being finished, the pasty mass is commonly allowed to cool and harden ere it is roughly powdered and boiled in water. Some manufacturers, however, plunge it at once, whilst still red-hot, into cold water, and fancy that some advantage is thus gained. In a theoretical view, the proper course would be to cover up the red-hot mass, so as to obstruct both the access of air and moisture, and thus prevent the decomposition of the cyanide of potassium during the process of cooling. As the prussiate of potash is extremely soluble in boiling water, the fused mass rapidly disintegrates beneath the action of this fluid; and, in a short time, the whole is resolved into a solution of the prussiate, carbonate, and sulphate of potash, and into an insoluble magma of carbon and scrap-iron. By filtration, the saline fluid is separated from the insoluble portion; and, after evaporation, furnishes crystals of prussiate of potash, mixed with sulphate of potash, which, by re-solution and crystallization, are rendered sufficiently pure for the market.

Some years ago, the Society of Arts presented their gold medal to Mr. L. Thompson, for his discovery of the manufacture of prussiate of potash by means of the nitrogen of the air; and several patents have since been taken out for improvements in the apparatus

needed to render this discovery available. The process is at present conducted on a large scale at Newcastle-upon-Tyne, and seems to answer the object contemplated. We have not, however, had an opportunity of becoming acquainted with its commercial advantages, though, on sanitary grounds, these are of the highest importance. The fact that atmospheric nitrogen can be brought into chemical union is, nevertheless, thoroughly established by this discovery, — which should therefore stimulate inventors to further efforts for utilising this great storehouse of azote. If nitrogen can be made to unite with carbon, why should it not also be made to combine with hydrogen, and thus produce ammonia? Twenty years ago the one of these combinations was seemingly as improbable as the other.

Much attention has of late been drawn to the cyanogen compounds evolved during the distillation of coal in the manufacture of gas; and it must be confessed that a wide field for improvement is opened in this direction. The quantity of cyanogen given off during the decomposition of one ton of common Newcastle coal is sufficient to produce about 7 pounds of Prussian blue, which, at the existing market price, would greatly exceed the total value of the coal. The cyanogen is most probably evolved in the form of cyanide of ammonium, and therefore requires protoxide of iron for the purpose of rendering it a fixed and permanent salt. Hence, if either the protoxide or peroxide of iron be placed, so that the gaseous constituents of the coal are made to pass through or over these oxides, a quantity of Prussian blue, and prussiate of ammonia, are generated; and this process may be repeated until almost the whole of the oxide of iron has been converted into ferrocyanic acid and Prussian blue. We have said, that the peroxide of iron will answer this end as well as the protoxide; but, in reality, it is still the protoxide which acts, for the impure coal-gas always contains sulphuretted hydrogen; and this, as is well known, has the property of reducing the peroxide of iron to the protoxide; consequently, both are equally efficacious in the production of ferrocyanic acid. When impure coal-gas, therefore, has been passed, for some time, over either of the oxides of iron, a substance results, from which prussiate of potash may be obtained, at a rate which must, one day, lead to the total suppression of the present mode of making that article. Let us suppose, for example, that a few pounds of oxide of iron have been mingled with sawdust, and subjected to the action of the impure gas arising from the distillation of 50 tons of coal: then sufficient cyanogen must have combined with the iron to generate 35 pounds of Prussian blue, and this too without the least expense. Now these 35 pounds of Prussian blue, when treated with caustic lime and sulphate of potash, would afford oxide of iron, sulphate of lime, and prussiate of potash, by double decomposition, — the latter of which would require only to be crystallized from the fluid in which it was dissolved; whilst the sulphate of lime and oxide of iron might be returned again to the position formerly occupied by the oxide of iron alone, and there made to combine with a fresh portion of cyanogen; and so on, time after time. We have seen some cwts. of prussiate of potash prepared in this way by Mr. Laming, of the Chemical Works, Millwall, and can answer for the purity and value of the article. Mr. Laming has also manufactured, in a similar manner, several beautiful samples of Prussian blue. There is, however, an art connected with the production of Prussian blue, which requires more than mere purity of materials; for if an inexperienced individual were to attempt to make a good marketable Prussian blue, even though possessed of the purest re-agents, he would certainly fail to bestow upon it the essential conditions of colour and cohesion, by which alone it attains a commercial value. The old mode of obtaining this article, in a proper state, was by precipitating a solution of common copperas, or protosulphate of iron, by a mixed solution of the carbonate and ferrocyanate of potash, and allowing the mixed precipitate of oxide and prussiate of iron to remain, for three weeks, in contact with the air; when it was, in technical language, "brightened" by the addition of a dilute acid, generally muriatic. The theory of this process appears to have been this — in the first place, protoxide and protocarbonate of iron were precipitated together, and these, by exposure to the air, passed into the state of peroxide of iron and Prussian blue; the peroxide of iron meanwhile acting mechanically, and preventing the particles of Prussian blue from cohering together and becoming one hard mass, as invariably happens when no such impediment to cohesion is present. Having attained this end, the dilute muriatic acid was employed to dissolve away the superfluous oxide of iron, and thus bring out the brilliancy of the blue colour, whilst it increased the peculiar spongy and friable nature of the product, and this, after copious ablutions of hot water, was next dried on a stone and sent to market. The practice of the present day is, however, much simpler and speedier than this; for, instead of 3 weeks, scarcely 3 days are now necessary for the production of Prussian blue. The plan generally followed is, to dissolve, in two separate portions of boiling water, exactly as much protosulphate of iron and prussiate of potash as will mutually decompose each other; and, for this purpose, nothing but actual experiment must be depended on, as the atomic numbers of these substances do not give a good result. Assuming,

however, that some given quantity of the one fluid has been found equal to a given proportion of the other, and that, when mixed and thrown on a filter, neither iron nor ferrocyanic acid can be detected in the filtered fluid, then the mixture is made in these proportions, and a quantity of recently-precipitated peroxide of iron having been added, the whole is rapidly boiled for several minutes; after which it is allowed to cool, and is then "brightened" by a dilute acid, copiously washed with warm water, dried on a stove, and rendered fit for the market. Prior to drying, the colour is very often brought down by the addition of inert colourless substances, such as starch, finely-ground rice, china clay, or alumina, according to the object of the manufacturer.

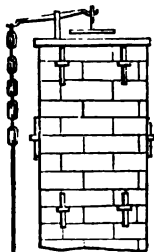
The fabrication of what is termed the red prussiate of potash has now assumed an important position in the arts, and is supposed by some to constitute a kind of secret in the trade. There is, however, in truth, nothing secret about it. The first method of forming this salt was by transmitting chlorine through a solution of the common prussiate of potash, until it ceased to precipitate the persalts of iron; and, as this implied some chemical skill on the part of the operator, the process came to be regarded as both difficult and secret; for an excess of chlorine not only constituted a waste, but, moreover, actually destroyed the red prussiate when formed, and thus led to a total failure. Now, however, this article is manufactured in the dry way, and the ill effects of an excess of chlorine are easily obviated. To prepare it a quantity of the ordinary yellow prussiate of potash must be reduced to a very fine powder, and subjected to the action of chlorine gas, with repeated agitation,—such, for example, as that which can be produced in a rotary churn. In this way the chlorine is rapidly absorbed, and chloride of potassium and red prussiate of potash generated. When it is found that the chlorine passes freely through the mixture, without being absorbed, the process must be stopped and the powder withdrawn. This powder, on being dissolved in the smallest possible quantity of water, heated to about 180° Fahr., will produce, on cooling, long needle-shaped crystals of the red prussiate of potash, which may be rendered purer and larger by recrystallization in the usual way; the chloride of potassium, meanwhile, remaining dissolved in the mother-liquor. It is far from improbable that this salt might be made by means of the permanganate of potash, or chameleon mineral, as the manganic acid parts with its oxygen with extreme facility when in solution. If this supposition should turn out to be correct, then a saving would occur in the process, even independently of the cost of chlorine,—for no chloride of potassium would be formed from the potash of the yellow prussiate. This subject merits a careful investigation by those interested in this branch of manufacture, for the red prussiate is rapidly extending in use amongst dyers and calico printers.

PRUSSIC ACID; Liebig's new test for. When some sulphuret of ammonium and caustic ammonia are added to a concentrated aqueous solution of prussic acid, and the mixture heated with the addition of pure flower of sulphur, the prussic acid is converted in a few minutes into sulphocyanide of ammonium. This metamorphosis depends on the circumstance, that the higher sulphurets of ammonium are instantly deprived by the cyanide of ammonium of the excess of sulphur they contain above the monosulphuret; for instance, if a mixture of prussic acid and ammonia be added to the pentasulphuret of ammonium, the solution of which is of a deep yellow colour, and the whole gently heated, the sulphuret of ammonium is soon discolored, and when the clear colourless liquid is evaporated and the admixture of sulphuret of ammonium expelled, a white saline mass is obtained, which dissolves entirely in alcohol. The solution yields on cooling or evaporation colourless crystals of pure sulphocyanide of ammonium. Only a small quantity of sulphuret of ammonium is requisite to convert, in presence of an excess of sulphur, unlimited quantities of cyanide of ammonium into sulphocyanide; because the sulphuret of ammonium, when reduced to the state of monosulphuret, constantly re-acquires its power of dissolving sulphur, and transferring it to the cyanide of ammonium. The following proportions will be found to be advantageous: 2 ounces of solution of caustic ammonia, of 0.95 specific gravity, are saturated with sulphuretted hydrogen gas; the hydrosulphuret of ammonia thus obtained is mixed with 6 ounces of the same solution of ammonia, and to this mixture 2 ounces of the flowers of sulphur are added; and then the product resulting from the distillation of 6 ounces of prussiate of potash, 3 ounces of the hydrate of sulphuric acid, and 18 ounces of water. This mixture is digested in the water bath, until the sulphur is seen to be no longer altered, and the liquid has assumed a yellow colour; it is then heated to boiling, and kept at this temperature until the sulphuret of ammonium has been expelled and the liquor has again become colourless. The deposit, or excess of sulphur is now removed by filtration, and the liquid evaporated to crystallization. In this way from 3½ to 3¾ ounces are got of a dazzling white dry sulphocyanide of ammonium, which may be employed as a reagent, and for the same purposes as the sulphocyanide of potassium: of the 2 ounces of sulphur added, half an ounce is left undissolved.

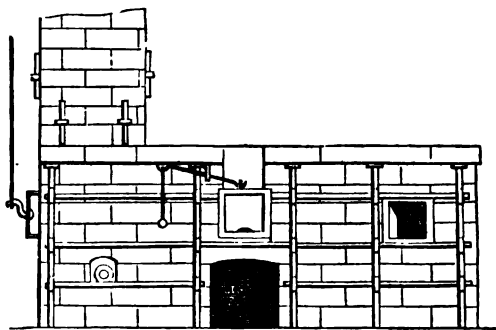
The habitude of the higher sulphurets of ammonium towards prussic acid, furnishes an admirable test for this acid. A couple of drops of a prussic acid which has been

diluted with so much water that it no longer gives any certain reaction with salts of iron by the formation of prussian blue, when mixed with a drop of sulphuret of ammonium, and heated on a watch glass until the mixture has become colourless, yields a liquid containing sulphocyanide of ammonium, which produces with persalts of iron a very deep blood red colour; and with persalts of copper, in presence of sulphurous acid, white sulphocyanide of copper.

PUDDLING OF IRON. This is the usual process employed in Great Britain for converting cast iron into bar or malleable iron—a crude into a more or less pure metal. The following plan of a puddling furnace has been deemed economical, especially with respect to fuel, as two furnaces are joined side by side together, and the workmen operate at doors on the opposite sides. *Fig. 1193.* represents this twin furnace



1193



in a side elevation; *fig. 1194.* in section, according to the line *x r*, in *fig. 1195.*, which exhibits a plan of the furnace. The various parts are so clearly shown in form and construction as to require no explanation. The total length outside is 14½ feet; width, 12½ feet; from which the dimensions of the other parts may be measured.

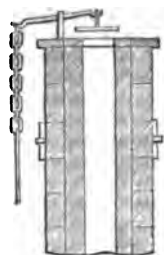
Iron is puddled either from cast pigs, or from the plates of the refinery (finery) furnace. In several iron-works a mixture of these two crude metals is employed. In the refining process, the waste at the excellent establishment of Mr. Jessop, at Codner Park, is from 2¼ to 2½ cwt. per ton; on which process the wages are 1s. per ton; and the coke, ¼ ton, worth 6s.; so that the total cost of refining per ton is 15s., when pig-iron is worth 3l. 10s.

The puddling is accompanied with a loss of weight of 1½ cwt. per ton; it costs in wages, for puddling refinery plates, 6s. 6d., and for pigs, 8s.; in which 18 cwt. of coal are consumed; value, 5s. per ton.

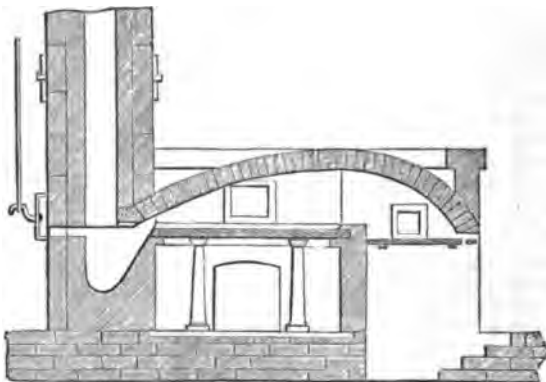
Shingling (condensing the bloom by the heavy hammer) costs, in wages, 1s. 9d. per ton; and rough-rolling, 1s. 2d. Cutting and weighing these bars cost 9d. for wages, including their delivery to the mill furnace, where they are re-heated and welded together. The mill furnace heating costs 1s. 6d. in wages, and consumes in fuel 12 cwt. of coals, at 5s. per ton. The rolling and straightening cost 5s. 6d.; cropping the ends, weighing, and stocking in the warehouse, 1s. for wages. Wear and tear of power, 5s. Labourers for clearing out the ashes, &c., 1s. 6d. per ton.

In Wales 4 tons of pig-iron afford upon an average only 3 tons of bars. From the above data a calculation may easily be made of the total expense of converting crude into cast-iron at the respective iron works.

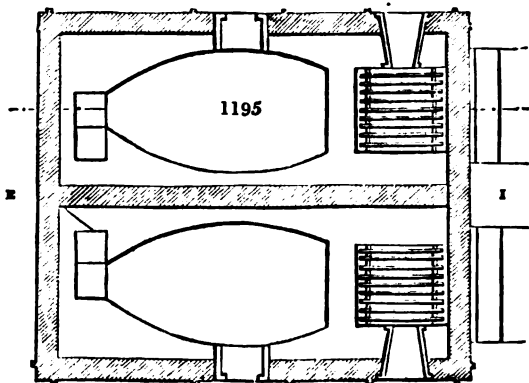
A great economy in the conversion of the cast into wrought metal seems about to be effected in our iron works, by the application of a current of voltaic electricity, to the crude iron in a state of fusion, whether on the hearth of the blast furnace, or on the fused



1194



pigs in the sand, or on the metal immediately on its being run from the finery furnace; the voltaic force of from 50 to 100 pairs of a powerful Smee's battery being previously arranged to act upon the whole train of the metal. This process, for which Mr. Arthur Wall has recently obtained a patent, is founded upon the well-established



fact, that when a compound is subjected to an electrical current, its negative and positive elements are detached from one another. Crude iron contains more or less carbon, sulphur, phosphorus, arsenic, oxygen, and silicon—bodies all electro-negative in relation to iron, which is electro-positive. When the impure iron, as it flows from the blast-furnaces, is subjected during its cooling and consolidation to a powerful stream of voltaic electricity, the chemical affinities by which its various heterogeneous components are firmly associated are immediately subverted, whereby, in the case of crude iron, the sulphur, phosphorus, &c., which destroy or impair its tenacity and malleability, become readily separable in the act of puddling. On this principle, I would explain the extraordinary effect of Mr. Wall's patent electric process, as performed in my presence in

the excellent iron-works of Mr. Jessop, at Codner Park, Derbyshire, where the electrified forge pigs discharge those noxious elements so copiously in the puddling furnace, as to become after a single re-heating, without piling or fagotting, brilliant bars of the finest fibrous metal. The bars so made have been subjected, under my inspection, to the severest proofs by skilful London blacksmiths, and they have been found to bear piercing, hammering, bending, and twisting, as well as the best iron in the market. I have also analysed the said iron with the utmost minuteness of chemical research, and have ascertained it to be nearly pure metal, containing neither sulphur nor phosphorus, and merely an inappreciable trace of arsenic. I can therefore conscientiously recommend Mr. Wall's patent process to iron-masters as one of the greatest, easiest, and most economical improvements, which that important art has lately received.

The pecuniary advantage of this process, in respect of saving labour and waste of material, has been estimated at one pound sterling per ton; but it is not yet practically worked out.

The effect of electrifying iron is displayed in a singular manner by the conversion into steel of a soft rod, exposed in contact with coke, for a few hours, to a moderate red heat; a result which I have witnessed and can fully attest.

PUMICE-STONE (*Pierre-ponce*, Fr.; *Bimstein*, Germ.); is a spongy, vitreous-looking mineral, consisting of fibres of a silky lustre, interlaced with each other in all directions. It floats upon water, is harsh to the touch, having in mass a mean sp. grav. of 0.914; though brittle, it is hard enough to scratch glass and most metals. Its colour is usually grayish white; but it is sometimes bluish, greenish, reddish, or brownish. It fuses without addition at the blowpipe into a white enamel. According to Klaproth, it is composed of, silica, 77.5; alumina, 17.5; oxide of iron, 2; potassa and soda, 3; in 100 parts. The acids have hardly any action upon pumice-stone. It is used for polishing ivory, wood, marble, metals, glass, &c.; as also skins and parchment. Pumice-stone is usually reckoned to be a volcanic product, resulting, probably, from the action of fire upon obsidiana. The chief localities of this mineral are, the Islands of Lipari, Ponsa, Ischia, and Vulcano. It is also found in the neighbourhood of Andernach, upon the banks of the Rhine, in Teneriffe, Iceland, Auvergne, &c. It is sometimes so spongy as to be of specific gravity 0.37.

PUOZZOLANA, is a volcanic gravelly product, used in making hydraulic mortar. See CEMENTS and MORTARS.

PURPLE OF CASSIUS, *Gold purple* (*Pourpre de Cassius*, Fr.; *Gold-purpur*, Germ.); is a vitrifiable pigment, which stains glass and porcelain of a beautiful red or purple hue. Its preparation has been deemed a process of such nicety, as to be liable to fail in the most experienced hands. The following observations will, I hope, place the subject upon a surer footing.

The proper pigment can be obtained only by adding to a neutral muriate of gold a mixture of the protochloride and perchloride of tin. Every thing depends upon this intermediate state of the tin; for the protochloride does not afford, even with a concentrated solution of gold, either a chestnut-brown, a blue, a green, a metallic precipitate, or one of a purple tone; the perchloride occasions no precipitate whatever, whether the solution of gold be strong or dilute: but a properly neutral mixture, of 1 part of crystallized protochloride of tin, with 2 parts of crystallized perchloride, produces, with 1 part of crystallized chloride of gold (all being in solution), a beautiful purple-coloured precipitate. An excess of the protosalt of tin gives a yellow, blue, or green cast; an excess of the persalt gives a red and violet cast; an excess in the gold salt occasions, with heat (but not otherwise), a change from the violet and chestnut-brown precipitate into red. According to Fuchs, a solution of the sesquioxide of tin in muriatic acid, or of the sesquichloride in water, serves the same purpose, when dropped into a very dilute solution of gold.

Buisson prepares gold-purple in the following way. He dissolves, first, 1 gramme of the best tin in a sufficient quantity of muriatic acid, taking care that the solution is neutral; next, 2 grammes of tin in aqua regia, composed of 3 parts of nitric acid, and 1 part of muriatic, so that the solution can contain no protoxide; lastly, 7 grammes of fine gold in a mixture of 1 part of nitric acid, and 6 of muriatic, observing to make the solution neutral. This solution of gold being diluted with $3\frac{1}{2}$ litres of water (about 3 quarts), the solution of the perchloride of tin is to be added at once, and afterwards that of the protochloride, drop by drop, till the precipitate thereby formed acquires the wished-for tone; after which it should beedulcorated by washing, as quickly as possible.

Frick gives the following prescription:— Let tin be set to dissolve in very dilute aqua regia without heat, till the fluid becomes faintly opalescent, when the metal must be taken out, and weighed. The liquor is to be diluted largely with water, and a definite weight of a dilute solution of gold, and dilute sulphuric acid, is to be simultaneously stirred into the nitro-muriate of tin. The quantity of solution of gold to be

poured into the tin liquor must be such, that the gold in the one is to the tin in the other in the ratio of 96 to 10.

Gold-purple becomes brighter when it is dry, but appears still as a dirty-brown powder. Muriatic acid takes the tin out of the fresh-made precipitate, and leaves the gold either in the state of metal or of a blue powder. At a temperature between 212° and 300° Fahr., mercury dissolves out all the gold from the ordinary purple of Cassius.

Relative to the constitution of gold-purple, two views are entertained: according to the first, the gold is associated in the metallic state along with the oxide of tin; according to the second, the gold exists as a purple oxide along with the sesquioxide or peroxide of tin. Its composition is differently reported by different chemists. The constituents, according to—

| | | Gold. | Tin oxide. |
|---|--------|--------|------------|
| Oberkampf, in the purple precipitate, are | - | 39·82 | 60·18 |
| | violet | 20·58 | 79·42 |
| | ditto | 30·725 | 69·275 |
| Berzelius | - | 30·19 | 69·81 |
| Buisson | - | 30·89 | 69·11 |
| Gay Lussac | - | 17·87 | 82·13 |
| Fuchs | - | | |

If to a mixture of protochloride of tin, and perchloride of iron, a properly diluted solution of gold be added, a very beautiful purple precipitate of Cassius will immediately fall, while the iron will be left in the liquid in the state of a protochloride. The purple thus prepared keeps in the air for a long time without alteration. Mercury does not take from it the smallest trace of gold. — *Fuchs' Journal für Chemie*, t. xv.

Purple of Cassius is best made according to the French Pharmacopœia, by dissolving 10 parts of acid chloride of gold in 2000 parts of distilled water; preparing in another vessel a solution of 10 parts of pure tin in 20 of muriatic acid, which is diluted with 1000 of water, and adding this by degrees to the gold solution as long as a precipitate is formed. The precipitate is allowed to subside, and is to be washed by means of decantation: it is then filtered and dried at a very gentle heat.

PURPLE OF MOLLUSCA, is a viscid liquor, secreted by certain shell-fish, the *Buccinum lapillus*, and others, which dyes wool, &c. of a purple colour, and is supposed to be the substance of the Tyrian dye, so highly prized in ancient Rome for producing the imperial purple. See DYEING.

PURPURIC ACID, is an acid obtained by treating uric or lithic acid with dilute nitric acid. It has a fine purple colour; but has hitherto been applied to no use in the arts.

PURPURINE, is the name of a colouring principle, supposed by Robiquet and Colin to exist in madder. Its identity is questionable.

PUTREFACTION, and its Prevention. The decomposition of animal bodies, or of such plants as contain azote in their composition, which takes place spontaneously when they are exposed to the air, under the influence of moisture and warmth, is called putrefaction. During this process, there is a complete transposition of the proximate principles, the elementary substances combining in new and principally gaseous compounds. Oxygen is absorbed from the atmosphere, and converted into carbonic acid; one portion of the hydrogen forms water with the oxygen; another portion forms, with the azote, the carbon, the phosphorus, and the sulphur respectively, ammonia, carburetted, phosphuretted, and sulphuretted hydrogen gases, which occasion the nauseous smell evolved by putrefying bodies. There remains a friable earthy-looking residuum, consisting of rotten mould and charcoal. Vegetables which contain no azote, like the ligneous part of plants, suffer their corresponding decomposition much more slowly, and with different modifications, but they are finally converted into vegetable mould. In this process, the juices with which the plants are filled first enter into the acetous fermentation under the action of heat and moisture; the acid thereby generated destroys the cohesion of the fibrous matter, and thus reduces the solids to a pulpy state. In the progress of the decomposition, a substance is lastly produced which resembles oxidized extractive, is soluble in alkalis, and is sometimes called *mould*. This decomposition of the plants which contain no azote, goes on without any offensive smell, as none of the above-named nauseous gases are disengaged. When vegetable matters are mixed with animal, as in the dung of cattle, this decomposition proceeds more rapidly, because the animalized portion serves as a ferment to the vegetable. Vegetable acids, resins, fats, and volatilized oils, are not of themselves subject to putrefaction.

The object of the present article is to detail the principles and processes, according to which, for various purposes in the arts, the destruction of bodies by putrefaction may be prevented, and their preservation in a sound state secured for a longer or a shorter time. See MEATS preserved.

L. CONDITIONS OF THE PREVENTION OF PUTREFACTION.

The circumstances by which putrefaction is counteracted, are, 1. the chemical change of the azotized juices ; 2. the abstraction of the water ; 3. the lowering of the temperature ; and 4. the exclusion of oxygen.

1. *The chemical change of the azotized juices.* — The substance which in dead animal matter is first attacked with putridity, and which serves to communicate it to the solid fibrous parts, is albumen, as it exists combined with more or less water in all the animal fluids and soft parts. In those vegetables also which putrefy, it is the albumen which first suffers decomposition ; and hence those plants which contain most of that proximate principle, are most apt to become putrid, and most resemble, in this respect, animal substances ; of which fact, mushrooms, cabbages, coleworts, &c., afford illustrations. The albumen, when dissolved in water, very readily putrefies in a moderately warm air ; but when coagulated, it seems as little liable to putridity as fibrin itself. By this change it throws off the superfluous water, becomes solid, and may then be easily dried. Hence those means which by coagulation make the albumen insoluble, or form with it a new compound, which does not dissolve in water, but which resists putrefaction, are powerful antiseptics. Whenever the albumen is coagulated, the uncombined water may be easily evaporated away, and the residuary solid matter may be readily dried in the air, so as to be rendered unsusceptible of decomposition.

In this way acids operate, which combine with the albumen, and fix it in a coagulated state, without separating it from its solution ; such is the effect of vinegar, citric acid, tartaric acid, &c.

Tannin combines with the albuminous and gelatinous parts of animals, and forms insoluble compounds, which resist putrefaction ; on which fact the art of tanning is founded.

Alcohol, oil of turpentine, and some other volatile oils, likewise coagulate albumen, and thereby protect it from putrescence. The most remarkable operation of this kind is exhibited by wood vinegar, in consequence of the *creosote* contained in it, according to the discovery of Reichenbach. This peculiar volatile oil has so decided a power of coagulating albumen, that even the minute portion of it present in pyrolignous vinegar is sufficient to preserve animal parts from putrefaction, when they are simply soaked in it. Thus, also, flesh is cured by wood smoke. Wood tar likewise protects animal matter from change, by the creosote it contains. The ordinary pyrolignous acid sometimes contains 5 per cent. of creosote.

In circumstances where a stronger impregnation with this antiseptic oil may be necessary, common wood vinegar may be heated to 167° F., and saturated with effloresced Glauber's salts, by which expedient the oil is separated and made to float upon the surface of the warm liquid ; whence it should be immediately skimmed off ; because by cooling and crystallizing, the solution would so diminish in density as to allow the oil to sink to the bottom ; for its specific gravity is considerably greater than that of water. This oil, which contains, besides creosote, some other volatile constituents, may be kept dissolved ready for use in strong vinegar or alcohol. Water takes up of pure creosote only 1 1/4 per cent. ; but alcohol dissolves it in every proportion.

The earthy and metallic salts afford likewise powerful means for separating albumen from its watery solution, their bases having the property of forming insoluble compounds with it. The more completely they produce this separation, the more effectually do they counteract putrefaction. The alkaline salts also, as common salt, sal ammoniac, saltpetre, and tartar, operate against putrescence, though in a smaller degree, because they do not precipitate the albumen ; but, by abstracting a part of its water, they render it less liable to become putrid. Among the earthy salts, alum is the most energetic, as it forms a subsalt which combines with albumen ; it is three times more antiseptic than common salt, and from seven to eight times more so than saltpetre. Muriate of soda, however, may be employed along with alum, as is done in the tawing of sheepskins.

The metallic salts operate still more effectually as antiseptics, because they form with albumen still more intimate combinations. Under this head we class the green and red sulphates of iron, chloride of zinc, the acetate of lead, and corrosive sublimate ; the latter, however, from its poisonous qualities, can be employed only on special occasions. Nitrate of silver, though equally noxious to life, is so antiseptic, that a solution containing only 1/100 of the salt is capable of preserving animal matters from corruption.

2. *Abstraction of water.* — Even in those cases where no separation of the albumen takes place in a coagulated form, or as a solid precipitate, by the operation of a substance foreign to the animal juices, putrefaction cannot go on, any more than other kinds of fermentation, in bodies wholly or in a great measure deprived of their water. For the albumen itself runs so much more slowly into putrefaction, the less water it is dissolved in ; and in the desiccated state, it is as little susceptible of alteration as any other dry vegetable or animal matter. Hence, the proper drying of an animal substance becomes a universal preventive of putrescence. In this way fruits, herbs, cabbages, fish, flesh,

may be preserved from corruption. If the air be not cold and dry enough to cause the evaporation of the fluids before putrescence may come on, the organic substance must be dried by artificial means, as by being exposed in thin slices in properly constructed air-stoves. At temperature under 140° F., the albumen dries up without coagulation, and may then be re-dissolved in cold water, with its valuable properties unaltered. By such artificial desiccation, if flesh is to be preserved for cooking or boiling, it must not be exposed, however, to so high a degree of heat, which would harden it permanently, like the baked mummies of Egypt. Mere desiccation, indeed, can hardly ever be employed upon flesh. Culinary salt is generally had recourse to, either alone or with the addition of saltpetre or sugar.

These alkaline salts abstract water in their solution, and, consequently, concentrate the aqueous solution of the albumen; whence, by converting the simple watery fluid into salt water, which is in general less favourable to the fermentation of animal matter than pure water and by expelling the air, they counteract putridity. On this account, salted meat may be dried in the air much more speedily and safely than fresh meat. The drying is promoted by heating the meat merely to such a degree as to consolidate the albumen, and eliminate the superfluous water.

Alcohol operates similarly, in abstracting the water essential to the putrefaction of animal substances, taking it not only from the liquid albumen, but counteracting its decomposition, when mixed among the animal solida. Sugar acts in the same way, fixing in an unchangeable syrup the water which would otherwise be accessory to the fermentation of the organic bodies. The preserves of fruit and vegetable juices are made upon this principle. When animal substances are rubbed with charcoal powder or sand, perfectly dry, and are afterwards freely exposed to the air, they become deprived of their moisture, and will keep for any length of time.

3. *Defect of warmth.*—As a certain degree of heat is requisite for the vinous fermentation, so is it for the putrefactive. If in a damp atmosphere, or in one saturated with moisture, if the temperature stand at from 70° to 80° F., the putrefaction goes on most rapidly; but it proceeds languidly at a few degrees above freezing, and is suspended altogether at that point. The elephants preserved in the polar ices are proofs of the antiseptic influence of low temperature. In temperate climates, ice-houses serve the purpose of keeping meat fresh and sweet for any length of time.

4. *Abstraction of oxygen gas.*—As the putrefactive decomposition of a body first commences with the absorption of oxygen from the atmosphere, so it may be retarded by the exclusion of this gas. It is not, however, enough to remove the aerial oxygen from the surface of the body, but we must expel all the oxygen that may be diffused among the vessels and other solida, as this portion suffices in general to excite putrefaction, if other circumstances be favourable. The expulsion is most readily accomplished by a moderate degree of heat, which, by expanding the air, evolves it in a great measure, and at the same time favours the fixation of the oxygen in the extractive matter, so as to make it no longer available towards the putrefaction of the other substances. Milk, soup, solution of gelatine, &c., may be kept long in a fresh state, if they be subjected in an air-tight vessel every other day to a boiling heat. Oxygenation may be prevented in several ways: by burning sulphur or phosphorus in the air of the meat receiver; by filling this with compressed carbonic acid; or with oils, fats, syrups, &c., and then sealing it hermetically. Charcoal powder recently calcined is efficacious in preserving meat, as it not only excludes air from the bodies surrounded by it, but intercepts the oxygen by condensing it. When butcher-meat is enclosed in a vessel filled with sulphurous acid, it absorbs the gas, and remains for a considerable time proof against corruption. The same result is obtained if the vessel be filled with ammoniacal gas. At the end of 76 days such meat has still a fresh look, and may be safely dried in the atmosphere.

II. PECULIAR ANTISEPTIC PROCESSES.

Upon the preceding principles and experiments depend the several processes employed for protecting substances from putrescence and corruption. Here we must distinguish between those bodies which may be preserved by any media suitable to the purpose, as anatomical preparations or objects of natural history, and those bodies which, being intended for food, can be cured only by wholesome and agreeable means.

A common method for preserving animal substances unchanged in property and texture, is to immerse them in a spirituous liquor containing about 65 or 70 per cent. of real alcohol. Camphor may also be dissolved in it, and as much common salt as its water will take up. A double fold of ox-bladder should be bound over the mouth of the vessel, in order to impede the evaporation of the watery portion of the liquid, and its upper surface should be coated with a turpentine varnish. Undoubtedly a little creosote would be of use to counteract the decomposing influence of the alcohol upon the

animal substances. With such an addition, a weaker spirit, containing no more than 30 per cent. of alcohol, would answer the purpose.

Instead of alcohol, a much cheaper vehicle is water saturated with sulphurous acid; and if a few drops of creosote be added, the mixture will become very efficacious. A solution of red sulphate of iron is powerfully antiseptic; but after some time it gives a deposit of the oxide, which disguises the preparation in a great degree.

According to Tauffier, animal substances may be preserved more permanently by a solution of one part of chloride of tin in 20 parts of water, sharpened with a little muriatic acid, than even by alcohol.

For preserving animal bodies in an embalmed form, mummy-like, a solution of chloride of mercury and wood vinegar are most efficacious. As there is danger in manipulating with that mercurial salt, and as in the present state of our knowledge of creosote, we have it in our power to make a suitable strong solution of this substance in vinegar or spirit of wine, I am led to suppose that it will become the basis of most antiseptic preparations for the future. From the statements of Pliny, it is plain that wood vinegar was the essential means employed by the ancient Egyptians in preparing their mummies, and that the odoriferous resins were of inferior consequence.

CURING OF PROVISIONS.

Flesh.—The ordinary means employed for preserving butcher meat are, drying, smoking, salting, and pickling or souring.

Drying of animal fibre.—The best mode of operating is as follows:—The flesh must be cut into slices from 2 to 6 ounces in weight, immersed in boiling water for 5 or 6 minutes, and then laid on open trellis-work in a drying-stove, at a temperature kept steadily about 122° F., with a constant stream of warm dry air. That the boiling water may not dissipate the soluble animal matters, very little of it should be used, just enough for the meat to be immersed by portions in succession, whereby it will speedily become a rich soup, fresh water being added only as evaporation takes place. It is advantageous to add a little salt, and some spices, especially coriander seed, to the water. After the parboiling of the flesh has been completed, the soup should be evaporated to a gelatinous consistence, in order to fit it for forming a varnish to the meat after it is dried, which may be completely effected within two days in the oven. By this process two-thirds of the weight is lost. The perfectly dry flesh must be plunged piece by piece in the fatty gelatinous matter liquefied by a gentle heat; then placed once more in the stove, to dry the layer of varnish. This operation may be repeated two or three times, in order to render the coat sufficiently uniform and thick. Butcher's meat dried in this way, keeps for a year, affords, when cooked, a dish similar to that of fresh meat, and is therefore much preferable to salted provisions. The drying may be facilitated, so that larger lumps of flesh may be used, if they be imbued with some common salt immediately after the parboiling process, by stratifying them with salt, and leaving them in a proper pickling-tub for 12 hours before they are transferred to the stove. The first method, however, affords the more agreeable article.

Smoking.—This process consists in exposing meat previously salted, or merely rubbed over with salt, to wood smoke in an apartment so distant from the fire as not to be unduly heated by it, and into which the smoke is admitted by flues at the bottom of the side walls. Here the meat combines with the empyreumatic acid of the smoke, and gets dried at the same time. The quality of the wood has an influence upon the smell and taste of the smoke-dried meat; smoke from beech wood and oak being preferable to that from fir and larch. Smoke from the twigs and berries of juniper, from rosemary, peppermint, &c., imparts somewhat of the aromatic flavour of these plants. A slow smoking with a slender fire is preferable to a rapid and powerful one, as it allows the empyreumatic principles time to penetrate into the interior substance, without drying the outside too much. To prevent soot from attaching itself to the provisions, they may be wrapped in cloth, or rubbed over with bran, which may be easily removed at the end of the operation.

The process of smoking depends upon the action of the wood acid, or the creosote volatilized with it, which operates upon the flesh. The same change may be produced in a much shorter time by immersing the meat for a few hours in pyrolignous acid, then hanging it up in a dry air, which, though moderately warm, makes it fit for keeping, without any taint of putrescence. After a few days' exposure, it loses the empyreumatic smell, and then resembles thoroughly smoked provisions. The meat dried in this way is in general somewhat harder than by the application of smoke, and therefore softens less when cooked, a difference to be ascribed to the more sudden and concentrated operation of the wood vinegar, which effects in a few hours what would require smoking for several weeks. By the judicious employment of pyrolignous acid diluted to successive degrees, we might probably succeed in imitating perfectly the effect of smoke in curing provisions.

Salting.—The meat should be rubbed well with common salt, containing about one sixteenth of saltpetre, and one thirty-second of sugar, till every crevice has been impregnated with it; then sprinkled over with salt, laid down for 24 or 48 hours, and, lastly, subjected to pressure. It must next be sprinkled anew with salt, packed into proper vessels, and covered with the brine obtained in the act of pressing, rendered stronger by boiling down. For household purposes it is sufficient to rub the meat well with good salt, to put it into vessels, and load it with heavy weights, in order to squeeze out as much pickle as will cover its surface. If this cannot be had, a pickle must be poured on it, composed of 4 pounds of salt, 1 pound of sugar, and 2 oz. of saltpetre dissolved in 2 gallons of water.

Pickling with vinegar.—Vinegar dissolves or coagulates the albumen of flesh, and thereby counteracts its putrescence. The meat should be washed, dried, and then laid in strong vinegar. Or it may be boiled in the vinegar, allowed to cool in it, and then set aside with it in a cold cellar, where it will keep sound for several months.

Fresh meat may be kept for some months in water deprived of its air. If we strew on the bottom of a vessel a mixture of iron filings and flowers of sulphur, and pour over them some water which has been boiled, so as to expel its air, meat immersed in it will keep a long time, if the water be covered with a layer of oil, from half an inch to an inch thick. Meat will also keep fresh for a considerable period when surrounded with oil, or fat of any kind, so purified as not to turn rancid of itself, especially if the meat be previously boiled. This process is called potting, and is applied successfully to fish, fowls, &c.

Prechtl says that living fish may be preserved 14 days without water, by stopping their mouths with crumbs of bread steeped in brandy, pouring a little brandy into them, and packing them in this torpid state in straw. When put into fresh water, they come alive again after a few hours! *Prechtl, Encyclop. Technologische, art. Fäulnis Abhaltung.*

Eggs.—These ought to be taken new laid. The essential point towards their preservation is the exclusion of the atmospheric oxygen, as their shells are porous, and permit the external air to pass inwards, and to excite putrefaction in the albumen. There is also some oxygen always in the air cell of the eggs, which ought to be expelled or rendered inoperative, which may be done by plunging them for 5 minutes in water heated to 140° F. The eggs must be then taken out, wiped dry, besmeared with some oil (not apt to turn rancid) or other unctuous matter, packed into a vessel with their narrow ends uppermost, and covered with sawdust, fine sand, or powdered charcoal. Eggs coated with gum arabic, and packed in charcoal, will keep fresh for a year. Lime water, or rather milk of lime, is an excellent vehicle for keeping eggs in, as I have verified by long experience. Some persons coagulate the albumen partially, and also expel the air by boiling the eggs for two minutes, and find the method successful. When eggs are intended for hatching, they should be kept in a cool cellar; for example, in a chamber adjoining an ice-house. Eggs exposed, in the holes of perforated shelves, to a constant current of air lose about $\frac{1}{3}$ of a grain of their weight daily, and become concentrated in their albuminous part, so as to be little liable to putrefy. For long sea voyages, the surest means of preserving eggs is to dry up the albumen and yolk, by first triturating them into a homogeneous paste, then evaporating this in an air-stove or a water-bath heated to 125°, and putting up the dried mass in vessels which may be made air-tight. When used, it should be dissolved in three parts of cold or tepid water.

Grain of all kinds, as wheat, barley, rye, &c., and their flour, may be preserved for an indefinite length of time, if they be kiln-dried, put up in vessels or chambers free from damp, and excluded from the air. Well dried grain is not liable to the depredations of insects.

To preserve fruits in a fresh state, various plans are adopted. Pears, apples, plums, &c. should be gathered in a sound state, altogether exempt from bruises, and plucked in dry weather before they are fully ripe. One mode of preservation is to expose them in an airy place to dry a little for eight or ten days, and then lay them in dry sawdust or chopped straw, spread upon shelves in a cool apartment, so as not to touch each other. Another method consists in surrounding them with fine dry sand in a vessel which should be made air-tight, and kept in a cool place. Some persons coat the fruit, including their stalks, with melted wax; others lay the apples, &c., upon wicker-work shelves in a vaulted chamber, and smoke them daily during 4 or 5 days with vine branches or juniper wood. Apples thus treated and afterwards stratified with dry sawdust, without touching each other, will keep fresh for a whole year.

The drying of garden fruits in the air, or by a kiln, is a well-known method of preservation. Apples and pears of large size should be cut into thin slices. From 5 to 6 measures of fresh apples, and from 6 to 7 of pears, afford in general one measure of dry fruit, (biffins). Dried plums, grapes, and currants are a common article of commerce.

Herbs, cabbages, &c., may be kept a long time in a cool cellar, provided they are covered with dry sand. Such vegetables are in general preserved for the purposes of

food by means of drying, salting, pickling with vinegar, or beating up with sugar. Cabbages should be scalded in hot water previously to drying; and all such plants, when dried, should be compactly pressed together, and kept in air-tight vessels. Tuberos and other roots are better kept in an airy place, where they may dry a little without being exposed to the winter's frost.

A partial drying is given to various vegetable juices by evaporating them to the consistence of a syrup, called a rob, in which so much of the water is dissipated as to prevent them from running into fermentation. The fruits must be crushed, squeezed in bags to expel the juices, which must then be insipiated either over the naked fire, or on a water or steam bath, in the air or in *vacuo*. Sometimes a small proportion of spices is added, which tends to prevent mouldiness. Such extracts may be conveniently mixed with sugar into what are called conserves.

Salting is employed for certain fruits, as small cucumbers or gherkins, capers, olives, &c. Even for peas such a method is had recourse to, for preserving them a certain time. They must be scalded in hot water, put up in bottles, and covered with saturated brine, having a film of oil on its surface, to exclude the agency of the atmospheric air. Before being used, they must be soaked for a short time in warm water, to extract the salt. The most important article of diet of this class is the *sour kraut* of the northern nations of Europe, (made from white cabbage,) which is prepared simply by salting; a little vinegar being formed spontaneously by fermentation. The cabbage must be cut into small pieces, stratified in a cask along with salt, to which juniper berries and carui seeds are added, and packed as hard as possible by means of a wooden rammer. The cabbage is then covered with a lid, on which a heavy weight is laid. A fermentation commences, which causes the cabbage to become more compact, while a quantity of juice exudes and floats on the surface, and a sour smell is perceived towards the end of the fermentation. In this condition the cask is transported into a cool cellar, where it is allowed to stand for a year; and indeed, where, if well made and packed, it may be kept for several years.

The excellent process for preserving all kinds of butcher meat, fish, and poultry, first contrived by M. Appert in France, and afterwards successfully practised upon the great commercial scale by Messrs. Donkin and Gamble, for keeping beef, salmon, soups, &c. perfectly fresh and sweet for exportation from this country, as also turtle for importation thither from the West Indies, deserves a brief description.

Let the substance to be preserved be first parboiled, or rather somewhat more, the bones of the meat being previously removed. Put the meat into a tin cylinder, fill up the vessel with seasoned rich soup, and then solder on the lid, pierced with a small hole. When this has been done, let the tin vessel thus prepared be placed in brine and heated to the boiling point, to complete the remainder of the cooking of the meat. The hole of the lid is now to be closed perfectly by soldering, whilst the air is rarefied. The vessel is then allowed to cool, and from the diminution of the volume, in consequence of the reduction of temperature, both ends of the cylinder are pressed inwards, and become concave. The tin cases, thus hermetically sealed, are exposed in a test-chamber, for at least a month, to a temperature above what they are ever likely to encounter; from 90° to 110° of Fahrenheit. If the process has failed, putrefaction takes place, and gas is evolved, which, in process of time, will cause both ends of the case to bulge, so as render them convex, instead of concave. But the contents of those cases which stand the test will infallibly keep perfectly sweet and good in any climate, and for any number of years. If there be any taint about the meat when put up, it inevitably ferments, and is detected in the proving process. Mr. Gamble's turtle is delicious.

This preservative process is founded upon the fact, that the small quantity of oxygen contained within the vessel gets into a state of combination, in consequence of the high temperature to which the animal substances are exposed, and upon the chemical principle, that free oxygen is necessary as a ferment to commence or give birth to the process of putrefaction.

I shall conclude this article with some observations upon the means of preserving water fresh on sea voyages. When long kept in wooden casks, it undergoes a kind of putrefaction, contracts a disagreeable sulphurous smell, and becomes undrinkable. The influence of the external air, is by no means necessary to this change, for it happens in close vessels even more readily than when freely exposed to the atmospherical oxygen. The origin of this impurity lies in the animal and vegetable juices which the water originally contained in the source from which it was drawn, or from the cask, or insects, &c. These matters easily occasion, with a sufficient warmth, fermentation in the stagnant water, and thereby cause the evolution of offensive gases. It would appear that the gypsum of hard waters is decomposed, and gives up its sulphur, which aggravates the disagreeable odour; for selenitic waters are more apt to take this putrid taint, than those which contain merely carbonate of lime.

As the corrupted water has become unfit for use merely in consequence of the admix-

ture of these foreign matters, for water in itself is not liable to corruption, so it may be purified again by their separation. This purification may be accomplished most easily by passing the water through charcoal powder, or through the powder of rightly calcined bone-black. The carbon takes away not only the finely diffused corrupt particles, but also the gaseous impurities. By adding to the water a very little sulphuric acid, about 30 drops to 4 pounds, Lowitz says that two-thirds of the charcoal may be saved. Undoubtedly the sulphuric acid acts here, as in other similar cases, by the coagulation and separation of the albuminous matters, combining with them, and rendering them more apt to be seized by the charcoal. A more effectual agent for the purification of foul water is to be found in alum. A dram of pounded alum should be dissolved with agitation in a gallon of the water, and then left to operate quietly for 24 hours. A sediment falls to the bottom, while the water becomes clear above, and may be poured off. The alum combines here with the substances dissolved in the water, as it does with the stuffs in the dyeing copper. In order to decompose any alum which may remain in solution, the equivalent quantity of crystals of carbonate of soda may be added to it.

The red sulphate of iron acts in the same way as alum. A few drops of its solution are sufficient to purge a pound of foul water. The foreign matters dissolved in the water, which occasion putrefaction, become insoluble, in consequence of oxidizement, like vegetable extractive, and are precipitated. On this account, also, foul water may be purified, by driving atmospheric air through it with bellows, or by agitating it in contact with fresh air, so that all its particles are exposed to oxygen. Thus we can explain the influence of streams and winds, in counteracting the corruption of water exposed to them. Chlorine acts still more energetically than the air in purifying water. A little aqueous chlorine added to foul water, or the transmission of a little gaseous chlorine through it, cleanses it immediately.

Water-casks ought to be charred inside, whereby no fermentable stuff will be extracted from the wood. British ships, however, are now commonly provided with iron tanks for holding their water in long voyages.

PYRITES, is the native bisulphuret of iron. Copper pyrites, called vulgarly mundick, is a bisulphuret of copper.

PYRO-ACETIC SPIRIT. (*Esprit pyro-acétique, Acétone, Fr.; Brennzlicher Essiggeist, Mehit, Germ.*) This liquid was discovered and described by Chenevix long before *pyrolyginous spirit* was known. It may be obtained by subjecting to dry distillation the acetates of copper, lead, alkalis, and earths; and as it is formed especially during the second half of the process, the liquor which comes over then should be set apart, separated by decantation from the empyreumatic oil, and distilled a second time by the heat of a water-bath. The fine light fluid which now comes over first, is to be rectified along with carbonate of potassa, or chloride of calcium. As pyro-acetic spirit usually retains, even after repeated distillations, a disagreeable empyreumatic smell, like garlic, a little good bone-black should be employed in its final rectification. According to Reichenbach, pyro-acetic spirit may be extracted in considerable quantity from beech tar. (See the next article.) The spirit thus prepared is a colourless limpid liquid, of an acid and burning taste at first, but afterwards cooling; of a penetrating aromatic smell, different from that of alcohol; of the spec. gravity 0.7921 at 60° F., boiling at 132° F., and remaining fluid at 5°. It consists ultimately of, carbon, 62.148; hydrogen, 10.453; oxygen, 27.329; or, of 1 proportion of carbonic acid + 2 prop. of olefiant gas + 1 prop. of water; or, 1 prop. of acetic acid — 1 prop. of carbonic acid. According to another view, it is composed of, 51.52 parts of concentrated acetic acid, and 48.488 of oil of wine, being double of the quantity in acetic ether. It is very combustible, and burns with a brilliant flame, without smoke. When treated by chlorine, it loses an atom of its hydrogen, and absorbs 2 atoms of chlorine. It is soluble in water, alcohol, ether, and is not convertible into ether by strong sulphuric acid. It is used for dissolving the resins commonly called gums, with which the bodies of hats are stiffened.

PYROGALLIC ACID, and some astringent substances which yield it. To procure the pyrogallie acid for examination, powdered nutgalls are treated with water, which is evaporated until an extract resembling catechu is obtained, which being sublimed in Mohr's apparatus gives about 10.3 per cent. of pure crystals of the acid. By analysis it was found that 0.312 yielded 0.65 carbonic acid, and 0.1345 water; this would be equal to

| | | | | | | | |
|------------|---|---|----------|------------|--------|-------|--------|
| 8 carbon | - | - | 611.480 | calculated | 57.61 | found | 57.60 |
| 4 hydrogen | - | - | 49.918 | do | 4.70 | do | 4.78 |
| 4 oxygen | - | - | 400.000 | do | 37.69 | do | 37.62 |
| | | | <hr/> | | <hr/> | | <hr/> |
| | | | 1061.398 | | 100.00 | | 100.00 |

In examining the substances which yield pyrogallic acid, Stenhouse states, that he could obtain pure tannin only from nutgalls, let his process be ever so carefully conducted. Pure tannin and gallic acid are the only substances which are known, by distillation, to yield pyrogallic acid. Taking advantage of this circumstance, he proceeded to test various substances for the presence of gallic acid, and to examine whether the tannin they contain is the same as that of nutgalls.

Sumach. Sumach, obtained from the small branches of *Rhus coriaria*, was digested in hot water, filtered, evaporated, and subjected to distillation. The fluid distilled over into the receiver gave no crystals of pyrogallic acid (owing to the empyreumatic oil and impurities passing over with it); but it evidently contained the acid and tannin, similar to that of nutgalls, an hypothesis which his subsequent analysis verified, for after treating a watery extract with alcohol, and again with ether, he obtained pure colourless crystals, which answered to the qualities of gallic acid, and on distillation yielded pyrogallic acid.

The tannin freed from gallic acid, subjected to distillation, yielded as much pyrogallic acid as the same quantity obtained from nutgalls would have given. He also succeeded in converting the tannin of sumach into gallic acid, by boiling it with dilute sulphuric acid. In treating tannin precipitated from sumach by sulphuric acid with alcohol and ether, he procured crystals of gallic acid; sumach, therefore, most closely resembles nutgall, for which it has long been a substitute in the arts. The quantity of tannin it contains is, however, considerably less.

Valonia. The acorn of *Quercus agrilops*. Dried extract of valonia gave on distillation no signs of pyrogallic acid: a concentrated solution was precipitated by size—the fluid was evaporated—the extract boiled with alcohol—the alcohol distilled over—and the extract treated with ether, yielding a small quantity of crystals having the properties of gallic acid, which, on distillation, gave pyrogallic acid, but in very limited quantity, about one-thirtieth of that of sumach. The solution of valonia, treated with sulphuric acid, gave but a trifling precipitate of tannin; distilled, it gave much charcoal, but no empyreumatic products. The fluid in the receiver was colourless, and had no traces of pyrogallic acid. The tannin of valonia differs materially from that of nutgalls.

Oak-Bark. The extract, treated as the former, gave no traces of pyrogallic acid: even in subjecting large quantities of a decoction to examination, he could not obtain crystals of gallic acid, which he concludes to exist in it in very minute quantities, if it exist in it. The tannin precipitated by sulphuric acid yielded no traces of pyrogallic acid on distillation, and appears, therefore, to differ from that of nutgalls.

Divi-Divi, imported from Carthage, is the pod of a leguminous shrub, the *Casalpinia coriaria* according to Balfour. The extract, subjected to distillation, yields no traces of pyrogallic acid; but the fluid, passing over into the receiver, has its characteristic signs. By treating in the manner above mentioned, pure crystals of gallic acid may be obtained from it, which, on distillation, yield pyrogallic acid. Sulphuric acid gave, with a concentrated solution, but a very small precipitate, which, dried and distilled, yielded no trace of pyrogallic acid, but much charcoal. Thence the tannin of divi-divi differs materially from that of nutgall. The quantity of mucilage which it contains precludes it from the use of dyes; but as it contains much tannin, it is largely used for tanning.

Kino. From the African kino he could obtain neither gallic acid, nor did the abundant precipitate produced by sulphuric acid, on distillation, show any traces of pyrogallic acid; nitric acid converted it into oxalic acid.

Catechu. Catechu contained no gallic acid, but catechu and a peculiar tannin, which is precipitated by sulphuric acid, and when boiled with dilute sulphuric acid is of a dark brown colour, like the tannin of oak-bark. It is insoluble in cold or hot water, alcohol, or ether, and but trivially soluble in a solution of strong alkalis. Distilled, it gave no traces of pyrogallic acid or pyrocatechin.

Catechin, the part of catechu insoluble in cold water, yields on distillation the pyrocatechin of Zarenger.

Salicin. Charles Gerhardt was induced again to undertake the analysis of this substance, on account of the modification of the atomic number of carbon by Dumas and Strass.

In 100 parts he found

| | | I. | II. |
|----------|---|--------|--------|
| Carbon | - | 55.28 | 55.24 |
| Hydrogen | - | 6.50 | 6.53 |
| Oxygen | - | 38.22 | 38.23 |
| | | 100.00 | 100.00 |

The quotients of these numbers, divided by the atomic weights, are,

| | | At | | In 100 parts |
|----------|---|------|----|--------------|
| Carbon | - | 1474 | 48 | 55.3 |
| Hydrogen | - | 1040 | 28 | 6.2 |
| Oxygen | - | 382 | 22 | 38.5 |

PYROLIGNITE OF LEAD. The pyrolignous acid employed in the manufacture of sugar of lead, ought to be tolerably free from empyreumatic substances, in order to yield a good product. The manufacturers of pyrolignous acid furnish (often under the name of muriate of lead) a product which is very brown by these empyreumatic admixtures, and which is prepared by saturating pyrolignous acid with litharge. In dyeing and printing, sugar of lead is chiefly used for the preparation of acetate of alumina; but as impure sugar of lead is prejudicial to the more delicate colours, pure sugar of lead, prepared from alcohol vinegar, can alone be employed for these, as well as for chrome yellow, chrome orange, &c.

Prof. Schnedermann, of Chemnitz, has discovered a method by which the sugar of lead may be obtained from pyrolignous acid in a sufficient state of purity for dyeing purposes. The rough pyrolignous acid is rectified in the usual manner, then super-saturated with slaked lime, and exposed to the air for 24 hours, during which time the mass is to be frequently stirred up. By the excess of lime, a great part of the empyreumatic matter, which forms with the lime a more or less brown and insoluble combination, is precipitated. The exposure to the air is necessary, because the empyreumatic matters become more oxidized, assume a deeper colour, and become fitted for combination with lime. The brown solution of the acetate of lime is thus separated in a suitable manner from the precipitate, and heated to boiling, when small quantities of a clear solution of chloride of lime are successively added as long as the liquid continues to become paler. After evaporating to dryness, the yellowish gray residue, which consists of acetate of lime, with a small proportion of chloride of calcium, is decomposed by sulphuric acid. If the acetate be intended to be obtained by distillation from this mixture, the sulphuric acid must be diluted with an equal volume of water.

In other cases, the sulphuric acid is not at all to be diluted, or only very slightly so, and added gradually to the decomposed residue, to avoid the generation of heat. The mixture is left standing for a short time; it is then to be diluted with water, and the clear water drawn off from the gypsum. In this case it is not advisable to previously dilute the sulphuric acid with water, as the gypsum then assumes a crystalline loose condition, subsides with difficulty, and contains much fluid.

In both cases the acetic acid contains a small quantity of muriatic acid, also sulphurous acid; and, in the latter case, also a small portion of gypsum. Oxide of lead is now to be added, and heat applied till the acid reaction is feeble. The precipitate retains sulphurous acid from the gypsum, and also sulphate of lead and chloride of lead. The solution of the acetate of lead yields a yellowish sugar of lead, containing a small portion of chloride of lead, but which is generally sufficiently pure for dyeing purposes, and can be still further purified by recrystallization.

PYROLIGNOUS ACID. In addition to what has been said under **Acetic Acid**, I shall here describe the process as conducted upon a great scale at an establishment near Manchester. The retorts are of cast-iron, 6 feet long, and 3 feet 8 inches in diameter. Two of these cylinders are heated by one fire, the flame of which plays round their sides and upper surface; but the bottom is shielded by fire-tiles from the direct action of the fire. 2 cwts. of coals are sufficient to complete the distillation of one charge of wood; 36 imperial gallons of crude vinegar, of specific gravity 1.025, being obtained from each retort. The process occupies 24 hours. The retort-mouth is then removed, and the ignited charcoal is raked out for extinction into an iron chest, having a groove round its edges, into which a lid is fitted.

When this pyrolignous acid is saturated with quicklime, and distilled, it yields one per cent. of pyroxylic spirit (sometimes called naphtha); which is rectified by two or three successive distillations with quicklime.

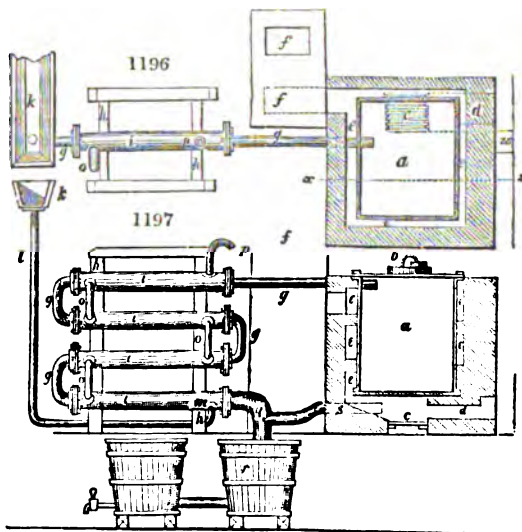
The tarry deposit of the crude pyrolignous acid being subjected to distillation by itself affords a crude pyro-acetic ether, which may also be purified by re-distillation with quicklime, and subsequent agitation with water.

The pyrolignite of lime is made by boiling the pyrolignous acid in a large copper, which has a sloping spout at its lip, by which the tarry scum freely flows over as it froths up with the heat. The fluid compound thus purified is syphoned off into another copper, and mixed with a quantity of alum equivalent to its strength, in order to form the red liquor, or acetate of alumina, of the calico-printer. The acetate of lime, and sulphate of alumina and potash, mutually decompose each other; with the formation of sulphate of lime, which falls immediately to the bottom.

M. Kestner, of Thann, in Alsace, obtains, in his manufactory of pyrolignous acid,

5 hectolitres (112 gallons imperial, nearly,) from a cord containing 93 cubic feet of wood. The acid is very brown, much loaded with tar, and marks 5° Baumé; 220 kilogrammes of charcoal are left in the cylinders; 500 litres of that brown acid produce, after several distillations, 375 of the pyrolignous acid of commerce, containing 7 per cent. of acid, with a residuum of 40 kilogrammes of pitch. For the purpose of making a crude acetate of lead (pyrolignite), he dries pyrolignite of lime upon iron plates, mixes it with the equivalent decomposing quantity of sulphuric acid, previously diluted with its own weight of water, and cooled; and transfers the mixture as quickly as possible into a cast-iron cylindrical still, built horizontally in a furnace; the under half of the mouth of the cylinder being always cast with a semicircle of iron. The acetic acid is received into large salt-glazed stone bottles. From 100 parts of acetate of lime, he obtains 133 of acetic acid, at 38° Baumé: it contains always a little sulphurous acid from the reaction of the tar and the sulphuric acid.

The apparatus represented in *figs.* 1196, & 1197. is a convenient modification of that



exhibited under acetic acid, for producing pyrolignous acid. *Fig.* 1196. shows the furnace in a horizontal section drawn through the middle of the flue which leads to the chimney. *Fig.* 1197. is a vertical section taken in the dotted line *x, x*, of *fig.* 1196. The chest *a* is constructed with cast-iron plates bolted together, and has a capacity of 100 cubic feet. The wood is introduced into it through the opening *b*, in the cover, for which purpose it is cleft into billets of moderate length. The chest is heated from the subjacent grate *c*, upon which the fuel is laid, through the fire-door *d*. The flame ascends spirally through the flues *e, e*, round the chest, which terminate in the chimney *f*. An iron pipe *g* conveys the vapours and gaseous products from the iron chest to the condenser. This consists of a series of pipes laid zigzag over each other, which rest upon a framework of wood. The condensing tubes are enclosed in larger pipes *i, i*; a stream of cold water being caused to circulate in the interstitial spaces between them. The water passes down from a trough *k*, through a conducting tube *l*, enters the lowest cylindrical case at *m*, flows thence along the series of jackets *i, i*, being transmitted from the one row to the next above it, by the junction tubes *o, o, o*, till at *p* it runs off in a boiling-hot state. The vapours proceeding downwards in an opposite direction to the cooling stream of water, get condensed into the liquid state, and pass off at *q*, through a discharge pipe, into the first close receiver *r*, while the combustible gases flow off through the tube *s*, which is provided with a stopcock to regulate the magnitude of their flame under the chest. As soon as the distillation is fully set agoing, the stopcock upon the gas-pipe is opened; and after it is finished, it must be shut. The fire should be supplied with fuel at first, but after some time the gas generated keeps up the distilling heat. The charcoal is allowed to cool during 5 or 6 hours, and is then taken out through an aperture in the back of the chest, which corresponds to the opening *u*, *fig.*

1196., in the brickwork of the furnace. About 60 per cent. of charcoal may be obtained from 100 feet of fir-wood, with a consumption of as much brush-wood for fuel.

Stoltze has ascertained, by numerous experiments, that one pound of wood yields from 6 to 7½ ounces of liquid products; but in acetic acid it affords a quantity varying from 2 to 5, according to the nature of the wood. Hard timber, which has grown slowly upon a dry soil, gives the strongest vinegar. White birch and red beech afford per pound 7½ ounces of wood vinegar, 1½ ounce of combustible oil, and 4 ounces of charcoal. One ounce of that vinegar saturates 110 grains of carbonate of potassa. Red pine yields per pound 6½ ounces of vinegar, 2½ ounces of oil, 3½ ounces of charcoal; but one ounce of the vinegar saturates only 44 grains of carbonate of potassa, and has therefore only two-fifths of the strength of the vinegar from the birch. An ounce of the vinegar from the white beech, holly oak (*Ilex*), common ash, and horse chesnut, saturates from 90 to 100 grains of the carbonate. In the same circumstances, an ounce of the vinegar of the alder and white pine saturates from 58 to 60 grains.

At Cornbrook works, near Manchester, cast-iron cylinders of 6 feet by 3 feet are employed, with square doors, on hinges, placed in the centre of the front of each cylinder. 6 tons of wood are carbonized by means of 1½ ton of coal. 24 hours are allowed for the process of carbonization. The cylinders are heated by one fire.

The Risca and Abercam works, both in Monmouthshire, and belonging to one proprietor, form conjointly the largest works of the kind in this country. At Risca, cast-iron cylinders, 6 feet by 4 feet, holding about ¾ of a cord of wood each, are employed, as, also, wrought iron chests, with an iron pipe, of 6 inches diameter, passing through to convey the heat to the interior of the chest, each of which is capable of holding 1½ cord of wood.

At Abercam, 8 square ovens, with boxes, are used, each oven being capable of containing 1 cord of wood. Twenty-four hours is usually allowed for carbonization; but a charge can be worked off in from twelve to sixteen hours, if required. At Chester works, large cylinders are employed, also a large square oven like that at Risca. The heated cast-iron pipe passing through the interior of the dense mass of wood very much assists its carbonisation. At Lougher, near Swansea, and also at Deptford, the following form of carbonizing apparatus is adopted:—a large circular sheet iron vessel is set in brickwork, having an aperture of particular shape and size in the top; within this carbonizer, the sheet iron vessels containing the wood are placed. These are of such a shape, that 6 of them, each 2 feet wide at one part, and 4 feet deep, form, when put together, a shape corresponding with that of the carbonizing vessel in which they are contained. As there is but one aperture in the carbonizer through which to introduce the six inner vessels containing the wood, a moveable framework is placed at the bottom of the carbonizer, by means of which each of the receptacles for the inner vessels are in turn brought under the aperture in the top of the cylinder, and receive the casing of wood destined for them. The aperture is then closed with a sheet iron lid, and luted in the ordinary manner.

The liquid products of the distillation of wood may be comprised under the heads of acid, spirituous, tarry, and oleaginous; the gaseous products are carbonic acid, olefiant gas, and light carburetted hydrogen. The relative proportions of charcoal, and of liquid and gaseous products, depend on the nature and quality of the wood employed, and the regulation of the temperature. Stoltze is quite right in his statement that the strongest acid is obtained from firm woods, of slow growth, in a dry soil; then those in moist grounds; and lastly, the weakest from pines and resinous trees, the product from these being much inferior to all the others.

To effect the carbonization of sawdust, spent bark, and other refuse materials, two processes have been recommended; the one that of Mr. A. P. Halliday, of Manchester, whose process is as follows. The raw material is introduced into a hopper, whence it is fed through a pipe by means of a screw revolving in the said pipe to the retort, which has also a screw of about the same diameter as the inside of the retort; a revolving motion to which being given, the material is passed gradually, in an agitated state, through the heated retort. At the extreme end of the retort two pipes branch off, one passing downwards and dipping into a vessel or cistern of water into which the carbonized substance falls; the other pipe passes upwards, for the conveyance of the gases given off during the destructive distillation of the material, through a main conduit pipe to the condenser, which may be constructed according to any of the approved modes now in use.

The other process is that patented by Messrs. Solomons and Azulay, which consists in passing super-heated steam into the mass, whereby the heating agent comes into actual contact with every particle of the vegetable mass, and effectually carbonizes it. A charcoal well adapted for artificial manures is thus obtained, as well as the ordinary products of the distillation of wood, which pass off with the steam. It may be urged

that the quantity of steam required for carbonization in passing off with the products of distillation, dilute them to such a degree as greatly to increase the quantity of fuel requisite for the evaporation of the acetate of lime or other acetate to be formed with it; this, however, is obviated by making the steam and heated vapours from the cylinder traverse a coil of pipe immersed in the solution to be evaporated, or pass through stills containing liquid to be distilled; all danger of the pipes being clogged up with tarry matter, as in the exit pipes of ordinary cylinders, being prevented by the passing of the steam.

Part II.—*Separation of the liquid products of distillation from each other.* The condensed liquid products before described form, by subsidence in the tank or receptacle, two layers, the lower composed of tarry and oily matters, and the upper containing the acid and spirituous parts of the products. If two tanks be provided, the one at a lower level than the other, the acid and spirituous liquor passes by means of an overflow pipe into the lower tank, and thus becomes separated from the tar; and if the acid liquor, in passing from one tank to the other, be made to traverse a suitable filter, a large portion of the tarry and oily matters held mechanically in suspension by the acid liquor will be returned.

The next process depends upon the method of working adopted at each particular manufactory, but without individual reference we may class them all under two heads. First, those who distil the pyroxylic spirit direct from the crude acid liquors; and, secondly, those who first neutralize the acid liquors with lime and then distil off the spirit. The first class employ copper stills of a capacity of about 500 gallons; into these the crude acid liquor is pumped, and heat applied either by means of steam made to traverse a coil of well-connected copper pipes placed within the still, as at Pitecombe Works, or the stills are heated externally, as at Cwm Avon Works. In the second case sheet-iron stills or boilers are employed, and the previously neutralized acid liquor run into them, and external heat applied, as at the Melanecrythan and other works. In each case about 100 gallons, or $\frac{1}{2}$ of the contents of the still, are distilled off and put by as containing all the pyroxylic spirit, the further distillation and purification of which we shall hereafter speak of. In the first case the remaining acid is next distilled off, and the residuary tarry liquor run off through a cock placed in the lower part of the still, or if distilled acid be not required, the remaining 400 gallons are run off into a suitable tank or reservoir, in which the tar settles to the bottom, and the acid liquor may be drawn off or pumped up for further use. In the second case the remaining 400 gallons of neutralized acid liquor, or acetate of lime solution, is run out of the still, and employed as will be hereafter described.

The tarry product of the distillation of wood is also distilled in copper or cast-iron stills, and the crude spirit obtained therefrom is added to that obtained from the distillation of the acid liquor above mentioned.

Part III.—*Manufacture of pyroxylic spirit or wood naphtha.* The crude and weak spirit, procured in the distillation before mentioned, is next subjected to repeated distillations in order to obtain the spirit in a more concentrated form, which is then rectified by distillation, first with lime alone, and lastly with a mixture of lime and caustic potash. In some works chalk is employed, and in others lime and bicarbonate of soda. For this purpose copper stills are employed, and steam heat applied, either through a coil of lead pipe placed within the still, or to the outside of the still, the lower half of which has been previously cased in an iron jacket. The pyroxylic spirit thus obtained is perfectly colourless, and is to be met with in the market of sp. grav. varying from 0.870 to 0.8320.

The quantity as well as quality of the pyroxylic spirit obtained at one works often differs much from that obtained at another works; the kind of wood has something to do with this, but management of the process much more. The quantity varies from $1\frac{1}{2}$ gallons to $2\frac{1}{2}$ or even 3 gallons per ton of wood employed.

The following table was constructed by Dr. Ure, with the view of showing the percentage of real spirit in pyroxylic spirit of different specific gravities. The wood spirit employed in the construction of this table was purified by distillation over powdered quicklime, and was drawn over with the heat of a water bath at such a temperature that its sp. grav. was 0.8136 at a temperature of 60° Fahr.

Mr. Scanlan, in the *Proceedings of the British Association*, 1855, gives .828 as the specific gravity, and 150° as the boiling point. "Wood spirit of 0.870 specific gravity," says Dr. Ure, "boils at 144° F., and if it be brought by distillation to spec. grav. 0.832, it boils at 140° F." The commercial wood spirit varies very much, both as to its spec. grav. and its power of dissolving gum sandarach, shellac, &c., from its containing acetone, anesite, &c., in variable proportions. The presence of these bodies is to be accounted for by variation in the modes employed for obtaining and purifying the wood spirit, as also by the more or less careful management of the several processes it is made to undergo. The question then naturally arises, how are we to judge of the quality of

| Specific Gravity. | Real Spirit per cent. | Over Excise proof. | Specific Gravity. | Real Spirit per cent. | Over or under-proof. |
|-------------------|-----------------------|--------------------|-------------------|-----------------------|----------------------|
| ·8136 | 100·00 | | ·9032 | 68·50 | 13·10 |
| ·8216 | 98·00 | 64·10 | ·9060 | 67·56 | 11·40 |
| ·8256 | 96·11 | 61·10 | ·9070 | 66·66 | 9·30 |
| ·8320 | 94·34 | 58·00 | ·9116 | 65·00 | 7·10 |
| ·8384 | 92·22 | 55·50 | ·9154 | 63·30 | 4·20 |
| ·8418 | 90·90 | 52·50 | ·9184 | 61·73 | 2·10 |
| ·8470 | 89·30 | 49·70 | | | Underproof. |
| ·8514 | 87·72 | 47·40 | ·9218 | 60·24 | 0·60 |
| ·8564 | 86·20 | 44·60 | ·9242 | 58·82 | 2·50 |
| ·8596 | 84·75 | 42·20 | ·9266 | 57·73 | 4·00 |
| ·8642 | 83·33 | 39·90 | ·9296 | 56·18 | 7·00 |
| ·8674 | 82·00 | 37·10 | ·9344 | 53·70 | 11·00 |
| ·8712 | 80·64 | 35·00 | ·9386 | 51·54 | 15·30 |
| ·8742 | 79·36 | 32·70 | ·9414 | 50·00 | 17·80 |
| ·8784 | 78·13 | 30·00 | ·9448 | 47·62 | 20·80 |
| ·8820 | 77·00 | 27·90 | ·9484 | 46·00 | 25·10 |
| ·8842 | 75·76 | 26·00 | ·9518 | 43·48 | 28·60 |
| ·8876 | 74·63 | 24·30 | ·9540 | 41·66 | 31·90 |
| ·8918 | 73·53 | 22·20 | ·9564 | 40·00 | 34·20 |
| ·8930 | 72·46 | 20·60 | ·9584 | 38·46 | 35·60 |
| ·8950 | 71·43 | 18·30 | ·9600 | 37·11 | 38·10 |
| ·8984 | 70·42 | 16·30 | ·9620 | 35·71 | 40·60 |
| ·9008 | 69·44 | 15·30 | | | |

wood spirit? will a knowledge of its spec. grav. or of its boiling point guide us in this respect? If a wood spirit be required for burning in a spirit lamp, or for singeing horses, there can be no doubt but that the spirit of the lowest spec. grav. is the best; but if the wood spirit be required for the manufacture of varnishes and polishes, especially those containing gum sandarach, then the above criterion will not apply. For instance, a sample of wood spirit containing 85 per cent. has been far preferred to that of another sample containing 95 per cent. We have invariably found that the wood spirit obtained by liming the crude liquor from the cylinders before distillation does not dissolve sandarach, whilst that obtained by distilling off the spirituous portion of the crude liquor before liming, is a good solvent of sandarach, the spirit in the first case being of a low spec. grav., and miscible with water, whilst the latter contained less real spirit, and was rendered milky on the addition of water.

At one set of works upwards of 2½ gallons per ton have been obtained on the average working of nearly 2,000 tons of wood; whilst at another a weekly consumption of 80 tons of wood has only yielded 160 gallons of pyroxylic spirit; and at a third, only 42 gallons have been obtained from 36 tons of wood.

Part IV.—*Manufacture of acetate of lime.* The commercial acetate of lime is of two qualities, respectively designated grey and brown lime salt; these are obtained by saturating with lime either the distilled acid before mentioned, or the undistilled acid after pyroxylic spirit has been removed by distillation, and evaporating the clear solution almost to dryness, or by evaporating the solution of acetate of lime as run off from the stills in the case in which the crude acid has been neutralized with lime previous to the distillation of the spirituous product. This saturation either of the crude acid previous to distillation, or the distilled acid, or the undistilled acid, is in either case performed in the same manner. The acid liquor is passed into wooden or iron vessels of convenient capacity, say from 500 to 1000 gallons each, and a quantity of either powdered chalk or of alaked and sifted lime, previously made into the consistence of cream with water, is added until the blue colour of litmus paper is no longer reddened; a slight excess of lime is then added, with a view to render the separation of the oily matters more complete. A portion of the tarry matters are carried to the bottom with the impurities of the chalk or lime employed, and part of the oily matters, combined with the lime, floats on the surface, and is removed by skimming. The solution of acetate of lime when clear, is ready for the evaporating pans, which are either wooden vessels lined with lead, and furnished with coils of wrought iron steam pipes in connexion with a boiler, or shallow pans of sheet iron, set over a naked fire—the boiling solution is repeatedly skimmed to remove the tarry matter floating on the surface; and the salt, as fast as formed, is fished out by means of large skimmers, and thrown into wicker baskets suspended over the pans, so that the liquor draining from the salt may not be

allowed to cool. The following practical result was obtained by the use of three sheet iron pans about 18 inches in depth, and capable of containing 450 gallons of acetate of lime liquor each. First six days of 24 hours each, 7020 gallons of liquor were evaporated, producing 78 cwt. of dry acetate of lime. Second week, 8060 gallons were evaporated, producing 92 cwt. of dry acetate. Third week, 7000 gallons were evaporated, producing 78 cwt. of dry acetate of lime. Two of the pans contained brown acetate of lime liquor, and the other grey acetate liquor.

The next part of the process is the drying of the drained acetate of lime. This is usually effected by placing it on the top of the mass of brickwork in which the retorts, or cylinders, or ovens, are set; but as there is seldom room to dry the whole of the salt in this way, many works are furnished with a drying house in addition, and, where the lime is made on the spot, the waste heat from the kiln or furnace is made available for drying the acetate, it being made to traverse the flues beneath the floor of the drying house. As a general rule, however, the drying of the acetate of lime is a part of the processes of this manufacture by no means well executed, requiring as it does more attention than the workmen are usually disposed to give to it.

Turf forms the best material for fuel, as it does not burn rapidly, and produces a steady and equal temperature.

Drying of the acetate of lime. When the furnace is thoroughly and equally heated, the flame of the fire is allowed to subside. If wood is employed as fuel, the sliding door should be opened at the commencement in order to allow the moisture to escape. The salt is transferred from the evaporating vessels to the drying plate, and spread out to the depth of 2 inches; and after the first portion has become somewhat dry, the depth is increased to 4 or 5 inches; the heat is preserved at the degree already mentioned for 24 hours, and during this time the salt is turned several times; subsequently when the mass appears to be becoming dry, the temperature may be increased to 100° (257° F.), so as to dry it completely. The mass is dry and properly roasted when it possesses the following characters. It must, before cooling, be brittle, easily crumbled between the fingers, mixed with blackish carbonaceous points or streaks, between which appear pieces of dry salt. A solution of the comminuted salt, in 4 or 6 times its volume of hot water, possesses a yellowish brown colour with a dark tinge, while previously it had a reddish brown colour. When the heat is increased towards the end of the process, as described, care must be taken to do it gradually, so that no smoke shall rise from the acetate, because it might thus be decomposed. Neither must any spark be permitted to come in contact with the acetate of lime; because, like sugar of lead, it possesses the property, in these circumstances, of catching fire and burning—by which the whole dry preparation would be completely destroyed. The treatment of the acetate of lime in this manner, by means of gradual drying, as experience has shown, possesses many advantages over the method of drying the salt in an open vessel; because there is no loss of acetic acid, as always occurs by the latter process. The operator has the preparation completely in his power, and with little expense of fuel and time, many hundred-weights of the salt can be prepared at once. This process does not merely extend to the removal of the moisture from the acetate of lime, but a chemical influence is exerted by means of it; because it is certain that the substances formed by dry distillation, which have been recently distinguished by Reichenbach, are partly dissipated by the heat, and partly decomposed, the acetate of lime possessing very different properties before and after the process. After the process the salt does not imbibe water so readily as it did previously. After solution, filtration, and evaporation, a much purer product is obtained than before, and upon the filter a resinous matter remains, the constituents of which have not yet been examined.

Part V.—Manufacture of Pyro-acetic spirit, or acetone. The usual mode of obtaining pyro-acetic spirit is by the decomposition of the acetates by means of heat. For this purpose the acetate is submitted to dry distillation in a retort, great attention being paid to the temperature, which should be kept as low as possible, consistent with the decomposition of the acetate employed. The distillation should be conducted with a slowly increasing heat, as the quicker the temperature is raised, the larger is the quantity of pyro-acetic spirit destroyed; carbon remains in the retort, and the empyreumatic oil formed renders the spirit impure. In the case of the metallic acetates, water, acetic acid, and pyro-acetic spirit, pass off in a state of vapour, and are condensed; carbonic acid, and carburetted hydrogen gases are the incondensable products, whilst the metallic base, mixed with some carbonaceous matter, remains in the retort. The metallic base is usually reduced to the metallic state, and the more difficult this reduction is, the greater is the quantity of pyro-acetic spirit formed.

Acetates, the bases of which contain carbonic acid at a red heat, produce, when heated in close vessels, the carbonate of the base and acetone. This takes place, for example, with the acetates of potassa, soda, and baryta. Where the oxide cannot retain carbonic acid at a red heat, as in the case of acetates of magnesia, zinc, or manganese, the

acetate is accompanied by carbonic acid. If the oxide be easily reducible, as in the acetates of copper, silver, and mercury, there are given off hydrated acetic acid, carbonic oxide, carbonic acid, water, and acetone, and there is left a mixture of the metal with carbon in a minute state of division.

In Thomson's *Inorganic Chemistry*, vol. ii. p. 93, edit. 1831, there is a table of the relative quantity of products obtained from the decomposition of several metallic acetates. The following extract shows the quantity of pyro-acetic spirit obtained.

| | | | | | | |
|-------------------|---|---|---|---|---|------|
| Acetate of silver | - | - | - | - | - | 0·00 |
| do. copper | - | - | - | - | - | 0·17 |
| do. nickel | - | - | - | - | - | 0·20 |
| do. iron | - | - | - | - | - | 0·24 |
| do. lead | - | - | - | - | - | 0·55 |
| do. zinc | - | - | - | - | - | 0·69 |
| do. manganese | - | - | - | - | - | 0·94 |

The acetates of potash, soda, lime, and baryta yield a much larger proportion of pyro-acetic spirit than any of the metallic acetates, and are therefore generally employed for this purpose, more especially the acetate of lime. It would appear that the acetates of silver and of baryta stand at the two extreme points of the list of acetates in respect to the production of pyro-acetic spirit; the former yielding only a concentrated acetic acid with not a trace of spirit, whilst the latter yields a liquid product almost entirely spirituous, with scarcely a trace of acid. The acetate of copper also yields but a small proportion of pyro-acetic spirit; hence its employment, as we shall subsequently notice, in the preparation of aromatic vinegar.

Dumas submitted to dry distillation 100 parts of acetate of baryta, composed of

| | | | | | | |
|-------------|---|---|---|---|---|-------|
| Baryta | - | - | - | - | - | 56·0 |
| Acetic acid | - | - | - | - | - | 37·4 |
| Water | - | - | - | - | - | 6·6 |
| | | | | | | 100·0 |

and capable therefore of yielding 21·5 per cent. of pyro-acetic spirit. The result of several experiments gave the following products:—

| | | | | | | |
|---------------------|---|---|---|---|---|-------|
| Carbonate of baryta | - | - | - | - | - | 72·2 |
| Charcoal | - | - | - | - | - | 1·2 |
| Pyro-acetic spirit | - | - | - | - | - | 18·3 |
| Water | - | - | - | - | - | 6·6 |
| Gas and loss | - | - | - | - | - | 1·7 |
| | | | | | | 100·0 |

On the supposition that the presence of the charcoal arose from the decomposition of a part of the pyro-acetic spirit, there would be about two per cent. of spirit to be added to the above, which would give near about the theoretical quantity. Taking the product at 18 per cent., one cwt. of acetate of baryta should furnish $2\frac{1}{2}$ gallons of pyro-acetic spirit. Not more than 2 gallons is obtained from the ordinary acetate of lime of commerce, and the results obtained by operating on some tons of this salt did not give even this amount of produce, no doubt on account of sufficient attention not having been given to the due regulation of the temperature. The acetate of lime was placed in shallow trays of about 2 ft. square and 2 inches in depth, and 15 or 16 of these trays placed over each other in an iron cylinder employed for the distillation of wood. The crude spirit is rectified by successive distillations over quick lime, when a limpid colourless fluid, spec. grav. 0·7921, is produced. It is soluble in water, alcohol, and ether, and burns with a whitish flame.

Part VII.—*Acetate of lead or sugar of lead. Manufacture of the brown acetate of lead or pyrolignite of lead.* The distilled pyrolignous acid is saturated with litharge in a tub, and the muddy solution ladled out into a large tun to settle, which it speedily does; the solution after settling is ladled into a pan, (malleable iron), or which may be made of cast-iron, 6 ft. long and 4 ft. broad. The solution is made to boil in this pan, and allowed to settle; it is then transferred into a large hemispherical pan, capable of holding about 300 or 400 gallons, when it is brought down to about crystallizing strength. When the solution has become dense enough to crystallize, about three times its bulk of water is run in upon it, whilst boiling, the solution being constantly stirred. By this treatment, a considerable quantity of pyrolignous matters may be skimmed off as fast as they rise to the surface; when they are removed, the evaporation goes on as before. If the solution be still too much coloured, another dose of water must be given. A little practice

soon enables us to know where the evaporation should be checked. The ordinary method is, to rinse a ladle (which is used to skim off the tar from the solution) through the liquid, and observe how many drops of solution fall from it before the solution takes a stringy appearance; if only 10 or 12 fall, then it is strong enough. The liquid is now ladled out into malleable iron pans, 5 ft. long, by 3 ft. broad, and about 6 inches deep, the sides being bevelled, or sloping outwards, from below upwards, to crystallize. After becoming sufficiently firm, the sugar of lead is taken out by inverting the pan on a cloth. The pots used in the above process are heated only at the bottom.

Manufacture of the white acetate of lead.—This is prepared by dissolving litharge in acetic acid; the acetic acid is first placed in a vessel, and the litharge added by degrees, well stirring the mixture until the solution does but slightly redden litmus paper; a quantity of water, equal to about one-half of the acid employed, is then run into the lead solution; heat is next applied, and the mixture slowly evaporated for about 12 hours, or until it has acquired a density of about 1.500. During evaporation any impurities which rise to the surface are skimmed off, and when the solution has acquired its proper density, it is run off into the crystallizing pans. When the mass of crystals become sufficiently hard to allow of its removal *en masse* from the crystallizers, it is drained and placed on wooden racks in the drying house, and when dry, cleaned and broken up into fragments for the market.

The mother liquor, containing neutral and basic acetates of lead and other metallic salts, may either be treated with vinegar, evaporated, recrystallized, and the residue employed as washings in subsequent operations, or it may be decomposed by carbonate of soda or lime, and used as carbonate of lead, or dissolved in acetic acid, and the supernatant acetate of soda or lime recovered.

The vessels employed in the manufacture of acetate of lead are in most cases made of lead. In Wales the mixing pans are of lead $\frac{3}{4}$ of an inch thick, 7 ft. long by 4 $\frac{1}{2}$ ft. wide, and 1 foot deep. Those pans are set on iron plates over arches, and the fireplaces are outside the building, in order that the acetate may not be darkened by the sulphurous vapours from the coal. The crystallizing pans are of wood lined with thin copper, and are about 4 ft. long by 2 ft. wide, and from 6 to 8 inches deep, sloping inwards at the edges. At Pitchcombe the mixing and crystallizing vessels are both of copper, having a strip of lead soldered down the sides and across the bottom of the vessel to render the copper more electro-negative: there is thus no action on the copper from the acetic acid. Great care is requisite in the drying of the sugar of lead; the temperature of the drying house should not exceed 90° Fahr. In Wales the heated air of a stove placed outside the drying house is conveyed through pipes passing round the interior; at other places steam heat is employed for this purpose, which is much to be preferred on account of its being more easily regulated.

We now come to speak of the product of sugar of lead from a given quantity of litharge. 112 lbs. of good Newcastle litharge should produce 187 lbs. of sugar of lead by the employment of 127 lbs. of acetic acid of spec. grav. 1.057, but not more than 180 lbs. is obtained in practice. In one set of works in Wales, a ton of Welsh litharge produces, with the acid obtained from 1 ton of acetate of lime, from 28 to 30 cwt. of sugar of lead; and in another manufactory 1 ton of best Newcastle litharge, with the acid from 1 ton and a half of acetate of lime, produced 33 cwt. of acetate.

The following process with metallic lead, recommended first by Berard, is easily executed, and is said by Runge to yield a good product with great economy. Granulated lead, the tailings in the white lead manufacture, &c., are put in several vessels, (say eight) one above the other, on steps, so that the liquid may be run from one to the other. The upper one is filled with acetic acid, and after half an hour, let off into the second, after another half hour into the third, &c., and so on to the last or eighth vessel. The acid causes the lead to absorb oxygen rapidly from the air, evolving heat, so that when the acid runs off from the lowest, it is thrown on the upper vessel for the second time; it forms a certain quantity of acetate of lead in solution, and after passing through the whole series is so strong that it may be evaporated at once to crystallize. There are two points of importance in this manufacture; whatever method may be pursued, they are to employ a strong acid, that less time and acid may be lost in concentrating the liquid, and to keep the solution always acid, to prevent the formation of a basic salt.

It may not be amiss to call attention here to a process patented about 10 years since for preparing acetate of lead and other acetates. This process consists in employing the acid in the state of vapour, to act upon the bases, instead of using it in the liquid form. A vessel is provided of adequate capacity for the quantity of acetate required, and constructed of such material as will not be readily destroyed by the acid. The top of this vessel is closed hermetically by a cover fastened down by any convenient means, and in the lower part of the vessel is placed either a minutely perforated false bottom, or a coiled tube of several convolutions, minutely perforated to admit vapour to pass through freely. To prevent the loss of acid, there is also placed, at different degrees of elevation, several

perforated diaphragms, similar to the false bottom just mentioned, on each of which is placed a layer of litharge, after which the cover of the vessel is to be accurately closed. By means of an ordinary distillatory apparatus, liquid acetic acid (strong or weak, pure or impure) is converted into vapour, which vapour is conducted by means of a pipe into the convoluted perforated pipe before mentioned, or between the real bottom of the vessel and the perforated false bottom; hence the vapour passing through the numerous perforations of the false bottoms and diaphragms, diffuses itself through every part of the vessel, its acid entering into combination with the base employed, and forming the acetate, which falls to the bottom of the vessel, and in its descent meets with the ascending streams of vapour, the acid of which renders it perfectly neutral; meanwhile the more aqueous parts of the vapour become liberated, and maintaining their temperature ascend, and in their passage through the successive layers of the base are thereby deprived of their remaining acid. The vapour thus reduced to simple steam is allowed to escape through one or more pipes at the top of the vessel; and as this stream still maintains a boiling temperature, it is conducted through a worm to evaporate the acetate, or the mother-liquor, by its heat. The distillation of the acid is continued until the acetate in the vessel is arrived at the proper degree of concentration for crystallization, which is easily ascertained by examining a small quantity drawn off by a cock at the bottom of the vessel, by which cock the whole contents are discharged when the operation is completed.

As the operation draws to its close, by nearly all the base having combined with the acid, the vapour issues out of the vessel, charged with a certain portion of acid; and in order that no loss may be sustained by its escape into the atmosphere, it is conducted into another vessel, prepared like the first mentioned, but charged super-abundantly with the base, to take up every particle of the acid issuing out of the first vessel, until the operation in that first vessel is ended. As the temperature of the solution of the acetate can never exceed that of the vapour, the crystalline product is of fine quality.

Part VIII. — *Manufacture of acetic acid.* In treating of the manufacture of acetic acid, we shall not enter upon any other processes, than those of the decomposition of the acetates, as effected either by heat or by sulphuric acid.

Acetic acid obtained by decomposition of the acetates by means of heat. — *Aromatic vinegar.* We have already mentioned, whilst speaking of the produce of pyro-acetic spirit, that when the acetates are submitted to dry distillation, acetic acid is produced. The following is another extract from the table then quoted, showing the quantity of acetic acid obtained by the decomposition of the metallic acetates:—

| | | | | | | |
|-------------------|---|---|---|---|---|---------|
| Acetate of silver | - | - | - | - | - | 107.309 |
| do. copper | - | - | - | - | - | 84.868 |
| do. nickel | - | - | - | - | - | 44.731 |
| do. iron | - | - | - | - | - | 27.236 |
| do. lead | - | - | - | - | - | 3.045 |
| do. zinc | - | - | - | - | - | 2.258 |
| do. manganese | - | - | - | - | - | 1.285 |

The crystallized acetate of copper is the salt most usually employed for this purpose. 20 pounds of the powdered acetate are placed in an earthen retort of the capacity of about two gallons, previously luted and exposed to the action of the fire; the elongated neck of the retort is connected with a tubulated receiver, and this with a second and third, the last of which is furnished with a Wetter's safety tube, dipping into water. The heat must at first be carefully applied, then gradually increased, and the operation regulated by the development of the gaseous products, which must not be too slow or too fast. The receivers must be kept cool. When on increasing the heat it is found that no vapours are given off, the fire must be put out, and the apparatus left to cool. The acid thus obtained has a greenish colour, its sp. gr. is 1.061. From 20 lbs. of acetate of copper rather more than $9\frac{1}{2}$ lbs. of rough acid are obtained. The residuum in the retort consists of 6½ lbs. of copper in a metallic state, mixed with a small quantity of charcoal. The crude acid thus obtained is next placed in a glass retort of the capacity of about $1\frac{1}{2}$ gallons, to which is adapted a tubulated receiver, and the retort is heated by means of a sand-bath. The first portions which come over are very weak, and the product should be kept separate until it comes over of a density of 1.072; the whole of the remaining product is now collected together, and the distillation continued to dryness. The acid obtained shows a sp. gr. of 1.080 to 1.088. The weaker products are redistilled, and the stronger portions mixed with the former. The $9\frac{1}{2}$ lbs. of crude acid furnish in this way 6 lbs. of pure acid, sp. gr. 1.085, 3 pounds at sp. gr. 1.042, and half a lb. of sp. gr. 1.023. The small portion of acetone which comes over with the acid, imparts an agreeable aroma to it, and the addition of camphor and essential oils constitutes the aromatic vinegar of commerce.

Manufacture of acetic acid, by the decomposition of acetate of soda by sulphuric acid. Any given quantity of crystallized acetate of soda is placed in a copper still, and a hollow place having been made in the mass of the crystals, a quantity of strong sulphuric acid, equivalent to 35 or 36 per cent, of the weight of the acetate of soda employed, is then poured in at once; the crystals forming the sides of the heap in the still are then pushed down into the acid, and the whole stirred with a long broad wooden spatula; the head is then put on and luted, and the connection made with the refrigerator. Nearly 4 cwt. of acetic acid, of sp. gr. 1.050, may thus be obtained from 3 cwt. of acetate of soda, which only requires to be passed through a calico filter (of the form described in Mohr and Redwood's *Practical Pharmacy*, page 203, fig. 211), on which some animal charcoal has been placed, to fit it for the market. A small quantity of acetic ether is often added to flavour it.

The still employed should be of stout copper, (the solder used in its construction should be silver solder), having its lower half set in an iron vessel, which either receives the high pressure steam to be used as the heating medium, or contains oil, tallow, or fusible metal, according as either of these substances may be preferred for use. In the former case a cock is placed at the lower part of the casing, to let off the condensed steam from time to time; and in the latter case the iron jacket is placed over the fire; the contents of the still receiving sufficient heat from the heated tallow, oil, or metal with which the copper still is in contact. A safety tube should be attached to permit the rise and escape of the heated oil, &c., should the temperature be raised too high.

The head of the still is of earthenware, and an earthenware, silver, or block tin worm may be employed to condense the acid vapour, according to the supply of water which can be obtained for condensation; or a series of Woulf's stoneware receivers, of about 20 galls. each, one third full of water, may be connected, with the head of the still. In this latter case, at the close of an operation, the acid in the first receiver will be found to be stronger than the second, the second than the third, &c.; and if the union of the contents of the whole series will not furnish an acid of the strength required, the stronger portions may be drawn off from the first and second receivers, and the weaker portions in the third and fourth receivers may be placed in the first and second for the next operation. A silver arm to connect the head with the earthenware worm is sometimes used, a regular supply of cold water being kept dripping on the metallic arm. The residuum left in the still after the distillation of the acid, is sulphate of soda, which should be in the state of an almost dry crystalline powder when the process has been well conducted; this may be dissolved in water, and the solution filtered, evaporated, and crystallized; or it may be used in the manufacture of acetate of soda.

Manufacture of glacial acetic acid.— Acetic acid may be obtained in a glacial state by using a dry acetate of soda from which the water of crystallization has been expelled by heat: to this is added about its own weight of strong oil of vitriol, sp. gr. 1.85. The first $\frac{2}{3}$ of the product should be collected separately, the last $\frac{1}{3}$ will crystallize.

Manufacture of acetic acid by the decomposition of acetate of lime by means of sulphuric acid.— Large quantities of this acid are employed in the manufacture of acetate of lead and other commercial acetates, white lead, and emerald green; also in the preparation of the inferior class of pickles, &c. &c. Much of the rough acid is sent from Wales to London, and purified by re-distillation. This rough acid is obtained in Wales and other parts of the country in the following manner:— A cast-iron cylinder, about 4 feet long, and 2 feet wide, closed at one end, is fitted with an iron rod passing through its interior, and furnished with numerous projecting pieces of iron; which reach almost from the centre rod to the inner sides of the cylinder. The other end of the cylinder is screwed on so as to be readily removed at any time when the cylinder is to be cleaned or repaired. This end is to be divided into 2 parts, one of which, occupying a space of about $\frac{2}{3}$ of the whole, is fixed on the upper part, the other $\frac{1}{3}$ is occupied by a moveable door, closing an aperture through which the contents of the cylinder may be removed; through this upper part one end of the iron rod above mentioned passes, and is attached to an handle, by means of which a rotary motion is communicated to the rod and its appendages, and the contents of the cylinder are kept in continual agitation. This vessel is termed an agitator. It is placed in a horizontal position on a mass of brickwork or masonry; at its upper part is an opening, through which the acetate of lime, sulphuric acid and water, are passed: motion is given by steam or manual power. When the mixture is complete, the door is opened, and the contents of the cylinder discharged into a tub or other vessel placed underneath the front of the cylinder. The pulpy mass is next transferred to shallow iron trays 2 feet wide, and from 2 to 4 feet in height, and 2 inches deep. These are placed in cast-iron cylinders about 5 feet long and 3 feet wide, and each layer of trays is separated, the one from the other, by means of iron rods placed between them; the cylinders are exposed to the direct action of the fire, and the acetic acid passes off in the form of vapour, which is condensed by passing it through leaden worms immersed in cold water.

This impure acid, which is contaminated with sulphurous acid and free sulphur, produced by the reaction of the tarry matter of the acetate of lime or the excess of the sulphuric acid, is then run into leaden vessels, placed in an iron cylinder and submitted to distillation. The liquid product is condensed by passing it through an earthenware worm. The acid in this state is employed in the manufacture of sugar of lead. 15 cwt. of brown acetate of lime, with 75 per cent. of sulphuric acid of sp. gr. 1.770, and 10 galls. of water, produce about 1550 lbs. of rough acid of sp. gr. 1.070. Sometimes a larger quantity of water is employed. On a small scale the following results were obtained:—

| Acetate of lime. | Sulphuric acid. | Water. | Acetic acid. | Sp. gr. |
|------------------|-----------------|--------|--------------|---------|
| lbs. | lbs. | lbs. | lbs. | |
| 12 Grey | - - 9 | - 15 | produced 23½ | 1.056. |
| 12 do. | - - 9 | - 10 | do. 17 | 1.073. |
| 12 Brown | - - 9 | - 15 | do. 18 | 1.050. |

On the large scale, 1½ ton of rough acetic acid, of sp. gr. 1.050 should be obtained from one ton of good acetate of lime, and $\frac{2}{3}$ of a ton of sulphuric acid. Acetate of lime may be so prepared, and the decomposition and rectifying processes so carried on, that the acid obtained is not readily distinguishable from that obtained from acetate of soda.

At some works copper stills, set over the naked fire, are employed, and the acid is redistilled in copper stills, set in a sand-heat. Iron stills of various sizes, with a flat cover, formed of magnesian limestone, or of a rough burnt clay, or of metallic tin, are also used. Large stills are not desirable, because towards the end of the distillation, decomposition of the acetic acid is readily effected in consequence of the destruction which a portion of the mass in contact with the bottom undergoes, whilst all the acid contained in it is being driven off. The distillation should be begun with a gentle fire, and should be carried on without much increasing the heat.

PYROLIGNOUS or PYROXYLIC SPIRIT, improperly called naphtha. This is employed, as well as pyroacetic ether, to dissolve the sandarach, shellac, and other resinous substances, which, under the name of gums, are used for stiffening the bodies of hats. I have already described, in the article PYROLIGNOUS ACID, how this spirit is obtained. Berzelius has found that the crude spirit may be best purified by agitating it with a fat oil, in order to abstract the empyreumatic oil; then to decant the spirit, distil it, first with fresh calcined charcoal, and next with chloride of calcium. The pyrolignous spirit, thus purified, is colourless, and limpid like alcohol; has an ethereous smell, somewhat resembling that of ants. Its taste is hot, and analogous to that of oil of peppermint. Its specific gravity, by my experiments, is 0.824. It readily takes fire, and burns with a blue flame, without smoke. It combines with water in any proportion; a property which distinguishes it from pyroacetic ether and spirit.

It is not easy to say what is the real chemical nature of pyroxylic spirit. There is no ultimate analysis of it that can be depended upon. The properties of the spirit examined by MM. Marcet and Macaire differ from those of our spirit, in refusing to combine with water, like alcohol. The article on sale in this country readily unites with water, and in all proportions with alcohol.

Test for distinguishing acetone from pyrolignous acid. As there are several fluids to be met under the name of naphtha, considerable doubt existed as to which of them should be used as "medical naphtha" by the compounder. The only tests relied upon, I believe, for a long time were miscibility of the naphtha with water without becoming milky, and its not being blackened by a drop or two of concentrated sulphuric or of nitric acid. Any "wood naphtha" met with in commerce, when repeatedly rectified over quick lime, will be found to stand these tests; and hence, when so rectified, was considered to be the proper naphtha to be used in medicine.

A question subsequently seems to have arisen as to the dependence to be placed upon these tests, and it was asked, Is it pyroacetic or pyroxylic spirit that should be used? and how are we to distinguish readily between the two? Accordingly we find this subject fully discussed in the *Pharmaceutical Journal* so far back as the year 1843, (vol. iii. p. 53.)

In this article upon naphtha, it is stated that pyroacetic spirit, or acetone, "is the kind of naphtha which Dr. Hastings uses;" and a mode of distinguishing this fluid from pyroxylic spirit, or ordinary wood naphtha, is pointed out, as suggested by Dr. Ure. It is the way in which nitric acid acts upon these two different substances. This test may be depended upon; but is almost dangerous, as nitric acid of spec. grav. 1.45 acts with explosive violence upon acetone.

Chloride of calcium affords us a much more ready and certain mode of distinguishing acetone from wood-spirit naphtha, the former having no action upon it, while the latter dissolves and combines with it. It will be found that a drop or two of a saturated solution of chloride of calcium, added to pyroacetic spirit in a test tube, is immiscible with it, and separates after agitation, whilst such a solution is instantly dissolved by the pyroxylic spirit.—*Maurice Scanlan.*

It should be ascertained beforehand, that the "naphtha" under examination does not separate into two fluids, or become milky on the addition of water.

On applying Mr. Scanlan's test, it was found that those specimens which had been most approved of as medicinal agents were pyroxylic spirit.

PYROMETER, is the name of an instrument for measuring high degrees of heat above the range of the mercurial thermometer. Wedgwood's is the one commonly referred to by writers upon porcelain and metallurgy; but a better one might be easily contrived.

PYROPHORUS, is the generic name of any chemical preparation, generally a powder, which inflames spontaneously when exposed to the air.

PYROTECHNY. See FIRE-WORKS.

PYROTECHNY FIRES; Blue, Green, and Red.

| | | | | |
|---|----|---|------|-----------|
| <i>Blue Fire.</i> —Nitre | - | - | - | 5 parts |
| Sulphur | - | - | - | 2 " |
| Metallic antimony | - | - | - | 1 " Mix. |
| <i>Green.</i> —Nitrate of barytes | - | - | - | 62½ parts |
| Sulphur | - | - | - | 10½ " |
| Chlorate of potash | - | - | - | 28½ " |
| Charcoal and sulphuret of arsenic of each | 1½ | " | Mix. | |
| <i>Red Fire.</i> —Dried nitrate of strontia | - | - | - | 72 parts |
| Sulphur | - | - | - | 20 " |
| Gunpowder | - | - | - | 6 " |
| Coal dust | - | - | - | 2 " Mix. |

The following recipes for the preparation of mixtures for coloured fires were found among the posthumous papers of the late Professor Marchand. The materials are rubbed to a fine powder separately, and then mixed with the hand.

| | | |
|---|--|--|
| <i>Red.</i> —61 p. c. chlorate of potash | | <i>Dark Violet.</i> —60 p. c. chlorate of potash |
| 16 sulphur | | 16 sulphur |
| 23 carbonate of strontia | | 12 carbonate of do. |
| | | 12 alum |
| <i>Purple-red.</i> —61 p. c. chlorate of potash | | <i>Pale Violet.</i> —54 p. c. chlorate of potash |
| 16 sulphur | | 14 sulphur |
| 23 chalk | | 16 carbonate of potash |
| | | 16 alum |
| <i>Rose red.</i> —61 p. c. chlorate of potash | | <i>Green.</i> —73 p. c. chlorate of potash |
| 16 sulphur | | 17 sulphur |
| 23 chloride of calcium | | 10 boracic acid |
| | | <i>Light Green.</i> —60 p. c. chlorate of potash |
| <i>Orange-red.</i> —52 p. c. chlorate of potash | | 16 sulphur |
| 14 sulphur | | 24 carbonate of baryta |
| 34 chalk | | |

For Theatrical Illumination.

| | | |
|---|--|--|
| <i>Yellow.</i> —61 p. c. chlorate of potash | | <i>White.</i> —64 p. c. nitre |
| 16 sulphur | | 21 sulphur |
| 23 dry soda | | 15 gunpowder |
| <i>or,</i> 50 p. c. nitre | | <i>or,</i> 76 p. c. nitre |
| 16 sulphur | | 22 sulphur |
| 20 soda | | 2 charcoal |
| 14 gunpowder | | <i>Red.</i> —56 p. c. nitrate of strontian |
| <i>or,</i> 61 p. c. nitre | | 24 sulphur |
| 17½ sulphur | | 20 chlorate of potash |
| 20 soda | | |
| 1½ charcoal | | <i>Green.</i> —60 p. c. nitrate of baryta |
| | | 22 sulphur |
| <i>Light Blue.</i> —61 p. c. chlorate of potash | | 18 chlorate of potash |
| 16 sulphur | | |
| 23 strongly calcined alum | | <i>Pink.</i> —20 p. c. sulphur |
| | | 32 nitre |
| <i>Dark Blue.</i> —60 p. c. chlorate of potash | | 27 chlorate of potash |
| 16 sulphur | | 20 chalk |
| 12 carbonate of copper | | 1 charcoal |
| 12 alum | | |

| | |
|--------------|--------------------------------|
| <i>Blue.</i> | 27 p. c. nitro |
| | 28 chlorate of potash |
| | 15 sulphur |
| | 15 sulphate of potash |
| | 15 ammonia-sulphate of copper. |

The dark blue is rendered still darker by the addition of some sulphate of potash, and ammonia-sulphate of copper.

PYROXILINE, is a name which I have ventured to give to a substance detected in pyroxilic spirit, by Mr. Scanlan, while residing in Dublin, and therefore called by him *Eblania*. I am indebted to that ingenious chemist for the following facts.

If potash water be added to raw wood-spirit (*pyroignous*), as long as it throws down any thing, a precipitate is produced, which is *pyroxiline*, mixed with tarry matter. The precipitate is to be collected on a filter cloth, and submitted to strong pressure between folds of blotting-paper; it is next to be washed with cold alcohol, spec. grav. 0.840, in order to free it from any adhering tarry matter; when the pyroxiline is left nearly pure. If it be dissolved in boiling alcohol, or hot oil of turpentine, it crystallizes regularly on cooling, in right square prisms, of a fine yellow colour, that look opaque to the naked eye, but when examined under the microscope, have the transparency and colour of ferrous sulphate of potash. Its turpentine solution affords crystals of a splendid orange-red colour, having the appearance of minute plates, whose form is not discernible by the naked eye, but when examined by the microscope, they are seen to be thin right rectangular prisms. The orange-red colour is only the effect of aggregation; for when ground to powder, these crystals become yellow; and under the microscope, the difference in colour between the two is very slight. Its melting point is 318° F. It sublimes at 300° in free air; heated in a close tube in a bath of mercury, it emits vapour at 400°; it then begins to decompose and is totally decomposed at 500°. Sulphuric acid decomposes it, producing a beautiful blue colour, which passes into crimson, as the acid attracts water from the atmosphere, and it totally disappears on plentiful dilution with water, leaving carbon of a dirty brown colour. Its alcoholic or turpentine solution imparts a permanent yellow dye to vegetable or animal matter.

Pyroxiline consists, according to the analysis of Drs. Apjohn and Gregory, of, carbon, 75.275; hydrogen, 5.609; oxygen, 19.116, in 100 parts.

Q

QUARTATION, is the alloying of one part of gold that is to be refined, along with three parts of silver, so that the gold shall constitute one *quarter* of the whole, and thereby have its particles too far separated to be able to protect the other metals originally associated with it, such as silver, copper, lead, tin, palladium, &c., from the action of the nitric or sulphuric acid employed in the subsequent parting process. See *REFINING*.

QUARTZ, has been described in the article *LAPIDARY*.

QUASSIA, is the wood of the root of the *Quassia excelsa*, a tree which grows in Surinam, the East Indies, &c. It affords to water an intensely bitter decoction which is occasionally used in medicine, and was formerly substituted by some brewers for hops, but is now prohibited under severe penalties. It affords a safe and efficacious fly-water, or poison for flies.

QUEEN'S WARE. See *POTTERY*.

QUEEN'S YELLOW, is an ancient name of Turbith Mineral, or yellow subsulphate of mercury.

QUERCITRON, is the bark of the *Quercus nigra*, or yellow oak, a tree which grows in North America. The colouring principle of this yellow dye-stuff has been called *Quercitrin*, by its discoverer Chevreul. It forms small pale yellow spangles, like those of *Aurum musivum*, has a faint acid reaction, is pretty soluble in alcohol, hardly in ether, and little in water. Solution of alum develops from it, by degrees, a beautiful yellow dye. See *CALICO-PAINING* and *YELLOW DYE*.

QUICKLIME; see *LIME*.

QUICKSILVER; see *MERCURY*.

On the Detection of Mercury in Cases of Poisoning. By MM. Danger and Flandin.

— The only progress of recent date in the toxicological study of mercury, is the discovery and use of Smithson's battery. The elements of this little apparatus consist of a plate of tin lined with a plate of gold in a spiral form. The tin constitutes the electro-negative, and the gold the electro-positive element. When immersed in a solution containing mercury, this pile separates the metallic element, which combines with

the gold, and imparts a white colour to it; at the conclusion the metal is volatilized in a small tube, to obtain it in the state of the characteristic fluid globule.

After a comparative examination of the reactions for discovering mercury in its solutions, we are satisfied that the galvanic or galvanoplastic action is the most sensitive. We have been able to detect by means of this test the mercury in a solution containing only $\frac{1}{10000}$ th.

It is not the galvanic apparatus which Smithson invented that we employed in our researches; we only preserved its principle. For toxicological researches, this ingenious instrument would have been subject to inconveniences which we wished to avoid: we substituted for the apparatus of the English chemist one in which the vessel containing the suspected liquid was inverted in a kind of funnel terminating in a tube drawn out to a bore which was almost capillary, so that the liquid might flow out of it at the rate of about 1 drop in 5 seconds; it was caught in a capsule. The flow could be regulated by varying the inclination of the apparatus. The electro-positive pole was placed in the capillary tube, the negative in the wide part of the funnel; they were placed nearly in contact, and both, or at least those parts which touch the liquid, should be made of pure gold. When the pile (Bunsen's), which consists of a single pair of plates, is in action, evolution of gas takes place at both poles, and the mercury contained in the solution is deposited upon the electro-positive pole, which it whitens. To be certain that this effect is produced by mercury, the metal need only be volatilized in a reduction-tube.

Being certain of detecting the slightest trace of mercury with this apparatus, we still had to find a suitable process for separating the mercury from the organic matters, and to isolate it from them as far as possible without loss. The Academy approved of the process of carbonization by sulphuric acid proposed by us, and this process is now generally practised in cases of medico-legal inquiry. We tested its application to the detection of mercury, and succeeded in this without having recourse to distillation, as we at first feared we should be obliged to do. After numerous trials we adopted the following process:—At a temperature of about 212° we liquefy the animal matters by one-third or half of their weight of monohydrated sulphuric acid in the ordinary manner. This liquefaction being completed, which requires only an hour and a half, or at the most two hours, the capsule is taken from the fire and left to cool to a certain extent. Then, after having placed the vessel underneath a chimney with a good draught, to protect the operator against the disengagement of vapours, we throw into the black carbonized liquid saturated chloride of lime in separate pieces, stirring the mixture at the same time with a glass rod. By degrees, as the matter thickens, and becomes white, distilled water is added, which favours the action of the chlorine, and this is continued until the liquid to be separated by filtration appears almost colourless. The quantity of chloride of lime must always be very nearly in relation to the amount of sulphuric acid required for the perfect liquefaction of the animal matters. For 3 ounces of silver, on account of the bile and fats which the liver contains, sometimes $1\frac{1}{2}$ ounces of sulphuric acid and $1\frac{1}{2}$ ounce of chloride of lime are necessary; but it is scarcely ever requisite to exceed this proportion. The substance, which is whitened and rendered of a chalky aspect, is well-moistened whilst cold with absolute alcohol, then diluted with distilled water and filtered, and the precipitate washed repeatedly. The liquid, if too abundant, is concentrated by evaporation, after which it is submitted to the action of a galvanic current, in the apparatus described. It was proved by experiment that the voltaic current favoured the precipitation of the mercury on the gold wire, and that in all cases it at least possessed the advantage of accelerating an operation, which without the concurrence of this action would perhaps require much time to accomplish.

The metal being obtained on the electro-positive conductor of the pile, it is necessary to wash the gold wire in boiling æther or alcohol to remove all fatty matter, and to dry it before introducing it into the reducing tube. This should be perfectly free from moisture, which might stain the globule of mercury, which is sometimes extremely small, and must be made perceptible to the eye.

The efficacy and sensitiveness of this process has been ascertained by numerous experiments. We have required 3 ounces only of the liver of an animal poisoned with corrosive sublimate to obtain an appreciable quantity of mercury from it. In future therefore it will not be more difficult to detect corrosive sublimate than arsenious acid, or any other metallic compound. — *Comptes Rendus*, March 31, p. 951, 1845.

QUILL. See FEATHERS.

QUINIDINE. — Put 100 grains of sulphate of quinine in a Florence flask with 5 ounces of distilled water; heat this to brisk ebullition; the sulphate of quinine ought to be entirely dissolved; add 2 ounces more water, and again heat it to ebullition; which ought to make a perfectly clear solution. If this be allowed to cool for 6 hours, and the crystals carefully dried in the open air on blotting paper, they will be found to

weigh about 90 gr.; the mother-liquor may be evaporated and tested with ether, when any cinchonine (or β quinine) will be easily detected. On examining sulphate of quinine of commerce from several leading manufacturers, I have found all of them give, within a grain or two, the same result, and, in each, indications of β quinine, though to an unimportant extent.

The above quantity of water (7 ounces) readily dissolves 800 gra. of sulphate of β quinine; and if 100 gra. of this salt are dissolved in 7 ounces of water, the crystals dried as above weigh only 54 gra., thus leaving 46 gra. in solution, instead of about 10 gr. — *Mr. R. Howard.*

QUININA. This medicine is now prepared in such quantities as to constitute a chemical manufacture. Quinina and cinchonina are two vegetable alkalis, which exist in Peruvian bark or cinchona; the pale or grey bark contains most cinchonina, and the yellow bark most quinina. The methods of extracting these bases are very various. In general, water does not take them out completely, because it transforms the neutral salts in the barks into more soluble acidulous salts, and into less soluble sub-salts. To exhaust the bark completely, one or other of the following solvents is employed: —

1. *Alcohol.* An extract by this menstruum is to be treated with very dilute warm muriatic acid, in order to dissolve every thing thus soluble; the acid liquor is to be saturated with magnesia, by boiling it with an excess of this earth; the precipitate is to be dried, filtered, and then exhausted by boiling-hot alcohol.

2. *Dilute acids.* Boil the bark, coarsely pounded, with eight times its weight of water, containing 5 per cent. of the weight of the bark of sulphuric acid. This treatment is to be repeated with a fresh quantity of dilute acid. The whole liquors must be filtered, the residuum strained, and the solution mixed with quicklime, equal to one fourth of the bark employed. This mixture, after having been well stirred, is to be strained, whenever it acquires an alkaline reaction, that is, tinges reddened litmus paper blue, or turmeric brown. The calcareous mass is to be now washed with a little water, and dried, and then boiled thrice with spirit of wine of sp. grav. 0.836. This solution being filtered, is to be mixed with a little water, and distilled. The bases cinchonina and quinina remain under the form of a brown viscid mass, and must be purified by subsequent crystallisation, after being converted into sulphates.

3. *An alkali, and then an acid.* — The object of this process is, to retain the vegetable alkalis in the bark, while with the alkaline water we dissolve out the acids, the colouring matters, the extractive, the gum, &c. Boil for an hour one pound of the bark with six pounds of water, adding by degrees a little solution of potash, so that the liquor may have still an alkaline taste when the boiling is over. Allow it to cool, filter, wash the residuum with a little water, and squeeze it. Diffuse it next in tepid water, to which add by degrees a little muriatic acid, till after a prolonged digestion the mixture shall perceptibly redden litmus paper. Filter the liquor, and boil it with magnesia. The precipitate being washed and dried, is to be treated with hot alcohol, which dissolves the quinina and cinchonina.

Obtained by any of the above methods, the quinina and cinchonina are more or less coloured, and may be blanched by dissolving them in dilute muriatic acid, and treating the solution with animal charcoal.

There are several methods of separating these two vegetable alkalis.

1. When their solution in spirit of wine is evaporated by heat to a certain point, the greater part of the cinchonina crystallizes on cooling while the quinina remains dissolved.

2. Digestion in ether dissolves the quinina, and leaves the cinchonina.

3. We may supersaturate slightly the two bases with sulphuric acid. Now as the supersulphate of quinina is sparingly soluble, the liquor need only to be evaporated to a proper point to crystallize out that salt, while the supersulphate of cinchonina continues in solution with very little of the other salt. Even this may be separated by precipitating the bases, and treating them, as above prescribed, with alcohol or ether.

One pound of bark rarely yields more than 2 drams of the bases. One pound of red bark afforded, to Pelletier and Caventou, 74 grains of cinchonina, and 107 grains of quinina. Quinina is composed of 75.76 carbon, 7.52 hydrogen, 8.11 azote, and 8.61 oxygen.

The salts of quinina are distinguished by their strong taste of Peruvian bark, and if crystallized, by their pearly lustre. Most of them are soluble in water, and some also in ether and alcohol. The soluble salts are precipitated by the oxalic, gallic, and tartaric acids, and by the salts of these acids. Infusion of nutgalls also precipitates them.

The sulphate of quinina is the only object of manufacturing operations. Upon the brownish viscid mass obtained in any of the above processes for obtaining quinina, pour very dilute sulphuric acid in sufficient quantity to produce saturation. The solution must be then treated with animal charcoal, filtered, evaporated, allowed to cool, when it deposits crystals. 1000 parts of bark afford, upon an average, 12 parts of sulphate. The sulphate of cinchonina, which is formed at the same time, remains dissolved in the mother waters.

The neutral sulphate of quina occurs in small transparent right prismatic needles. By spontaneous evaporation of their solution, larger crystals may be procured. They contain 24½ per cent. of water; and, therefore, melt when exposed to heat. They dissolve in 11 parts of water at ordinary temperatures; are much more soluble in hot spirit of wine, somewhat dilute, than in cold; and are nearly insoluble in anhydrous alcohol. If they be well dried, they possess the property of becoming luminous when heated a little above the boiling point of water, especially when they are rubbed. The sulphate is, in this case, charged with vitreous electricity. This is the sub-sulphate of some chemists.

There is a sub-sulphate, but it is applied to no use. The effloresced sulphate, called by some bisulphate, is preferred for medical practice. The extensive sale and high price of sulphate of quina, have given rise to many modes of adulteration. It has been mixed with boracic acid, margaric acid, sugar, sugar of manna, gypsum, &c. By incinerating a little of the salt upon a slip of platina, the boracic acid and gypsum remain while the quina is dissipated; sugar and margaric acid exhale their peculiar smoke and smell; or they may be dissolved out by a few drops of water. Cinchonina may be detected by adding ammonia to the solution, and treating the precipitate with ether, which leaves that vegeto-alkali.

Sulphate of Quinine tested.—A solution of sulphate of quinine being mixed with chlorine water, and then with caustic ammonia, produces a beautiful emerald-green colour. If an excess of concentrated solution of the ferrocyanide of potassium be added instead of ammonia, a dark-red colour is instantly produced, which after some hours passes into green, especially when exposed to light. This reaction is characteristic of quinine. If caustic potash is used instead of the ammonia, the solution acquires a sulphur-yellow colour. These reactions do not take place with cinchonine.

Determination of the quantity of water.—2·5 grammes of sulphate taken from a bottle the contents of which were thoroughly mixed, were dried in a closet heated by boiling water. The loss was 0·39 gr., answering to 15·6 per cent. of water, or to 7 equivalents and a half. This quantity of water is that which is usually found in the half effloresced sulphate of commerce.

This sulphate does not redden on the addition of concentrated sulphuric acid, and does not contain *salicine*.

When concentrated sulphuric acid is added, it assumes a very pale greenish yellow colour, which might be supposed to indicate the presence of a small quantity of *phloridzine*. But as it does not undergo the least coloration when exposed under a receiver to the vapour of liquid ammonia, it is evident that that substance is not present.

This sulphate is very slightly soluble in cold spirit, containing 90 per cent. of alcohol; but it dissolves *completely and very rapidly on the application of moderate heat*. This experiment shows that it contains neither *gum*, *fecula*, *sulphate of lime*, *sugar of milk*, nor even *sugar*.

This sulphate is completely soluble with heat in water acidulated with sulphuric acid; it therefore contains neither *fatty acid* nor *sub-resin*.

Test by Baryta.—In order to ascertain if the sulphate of quinine contains *sugar*, *salicine*, *phloridzine*, *mannite*, &c. and to effect the separation of one from the other of these substances, the addition of baryta water to the dissolved sulphate has been recommended; but whether we operate thus, or triturate the pulverized sulphate with an excess of baryta-water during some length of time, we can only succeed in producing a sub-sulphate of quinine, sensibly soluble in cold water, and partaking, in common with quinine itself, of the property of becoming insoluble on the application of heat. *To detect the presence of sulphate of cinchonine* 2·5 grammes of sulphate of quinine, taken from a perfect mixture of the sulphate contained in a bottle of 30 grammes, were introduced into a bottle with 15 grammes of liquid ammonia. After having thoroughly agitated the mixture, it was allowed to stand for 24 hours, in order to be certain of the entire decomposition of the sulphate. It was then heated in a water bath, so as to almost entirely volatilize the excess of ammonia; then left to cool, and 30 grammes of *pure* ether added. By agitation, the quinine rapidly and entirely dissolved, so that two superposed *transparent* liquids were in the bottle,—namely, the water containing the sulphate of ammonia and the ether containing the quinine. This experiment, which is very accurate, proved to us that the sulphate of quinine submitted to our examination did not contain sulphate of cinchonine.

Adulteration of Sulphate of Quinine.—The high price of the genuine Bolivian *Cinchona Calisaya*, through the monopoly of its export, has given occasion to imports from other districts of *Cinchonas*, the quality of which widely differs from that of the *Calisaya*, inasmuch as they contain principally quiniidina. The lower prices of these barks, regardless of their different constituents, have brought them quickly into use in many manufactories of quinine, whereby a large quantity of quinine containing quiniidina has got into the market, causing an undue depreciation in the price of quinine.

The existence of this third cinchona-alkaloid is now established beyond a doubt by ultimate analysis, by the peculiarity of its salts, and by important distinctive tests; and there can be no further question that quinidine must, equally with cinchonine, be distinguished from quinine. The external characters of sulphate of quinidine differ from those of sulphate of quinine: it has a greater specific gravity, and less flocculent crystallisation. In dry warm air it parts with its water of crystallization without deliquescing or losing its crystallized aspect; lastly, it is far more soluble than sulphate of quinine in cold water and in alcohol.

One of the distinctive properties of the three alkaloids in question—viz. their behaviour with ether—places in our hands a ready means of detecting the mixture of cinchonine and quinidine with quinine. Schweitzer (*Land. Med. Gazette*, vol. xxi. p. 175.) has already employed ether for the detection of cinchonine with complete success; and his process has with justice been subsequently quoted in most manuals, as it answers its purpose completely. Cinchonine is known to be entirely insoluble in ether, whatever may be the quantity of ether employed. The solubility of quinidine in ether, as compared with that of quinine, is but slight; ten grains of pure sulphate of quinine dissolve in 60 drops of ether, and 20 drops of spirit of ammonia; while 1 gr. of sulphate of quinidine is soluble in the same quantity of fluid; and in proportion, quinine containing quinidine will always be less soluble than pure sulphate of quinine.

Guided by this fact, I can recommend the following simple and very convenient process for the detection of quinidine and cinchonine:—

10 grains of the salt to be examined is to be put into a strong test-tube, furnished with a tight-fitting cork; to this are to be added 10 drops of diluted sulphuric acid (1 acid with 5 water), with 15 drops of water, and a gentle heat applied to accelerate the solution. This having been effected, and the solution entirely cooled, 60 drops of officinal sulphuric ether with 20 drops of spirits of ammonia must be added, and the whole well shaken, while the top is closed by the thumb. The tube is then to be closely stopped, and shaken gently from time to time, so that the bubbles of air may more readily enter the layer of ether.

If the salt examined be free from cinchonine and quinidine, or contain the latter in no greater proportion than 10 per cent., it will be completely dissolved; while on the surface, when contact of the two layers of clear fluid takes place, the mechanical impurities only will be separated (in which respect the various sorts of commercial quinine differ). After some time longer the layer of ether becomes hard and gelatinous, after which no further observation is possible.

From the above statement respecting the solubility of quinidine in ether, it appears that the 10 grains of the salt to be examined may contain 1 grain of quinidine, and still a complete solution with ether and ammonia may follow; but in this case the quinidine will shortly begin to crystallize in a layer of ether. The last trace of quinidine may be yet more definitively detected by employing, instead of the ordinary ether, some ether previously saturated with quinidine, by which means all of the quinidine contained in the quinine must remain undissolved. It is particularly requisite in performing this last experiment to observe, after the shaking, whether all has dissolved; for, owing to the great tendency of quinidine to crystallisation, it may become again separated in a crystalline form, and be a source of error.

If more than $\frac{1}{10}$ th of quinidine or cinchonine be present, there will be found an insoluble precipitate at the limits of the two layers of fluids. If this be quinidine, it will be dissolved on the addition of proportionately more ether, while cinchonine will be unaffected.

It is expressly to be remarked, that the necessity for testing sulphate of quinine in search of other fraudulent adulterations is not superseded by the above described process.

We have particularly to determine upon the absence of inorganic substances, which may be effected by subjecting to red heat on a platinum dish, or simply by solution in alcohol.

Gypsum, chalk, magnesia, &c., will be left undissolved. Boracic acid will be dissolved by alcohol, but its green flame will indicate its presence in the alcoholic solution when ignited.

The absence of organic substances, such as salicine, sugar, stearic acid, &c., may be inferred from the formation of a colourless solution with pure concentrated cold sulphuric acid: it is as well to leave the sulphuric acid to act for some hours.

The presence of sal-ammoniac may be detected by the addition of caustic potash to the suspected salt, when, if present, it will be known by the diffusion of the ammoniacal odour.

On the preparation of Sulphate of Quinine for Hospitals, by Mr. Edward Herring.—

"This is simply the known article of sulphate of quinine crystallized, but not so white in point of colour as the usual article of commerce.

"You are aware that the whiter salt is brought to its snow white hue by the agency of animal charcoal, the action of sulphuric acid therefore on the lime and lime salts of the charcoal, forming sulphate of lime, is likely to be present in the white kind, unless very carefully prepared. This hospital sulphate runs no chance of such impurities, as the published process, when patented, will show.

"The price at which it is introduced is perhaps of no moment to you, but it may be interesting to you to know that it will cost consumers about 20 per cent. less than the white kind. Independently, therefore, of its purity, I expect this great saving will not be the least of its recommendations.

"The bark is boiled in a solution of caustic soda. This extracts the colouring matter and gum of the bark: it is pressed, washed with cold water, and again boiled with caustic potash—again pressed, washed, and again pressed. The bark is now free of all colouring, and hence obviating the use of animal charcoal, unless the sulphate is required to be quite white—in which case I use pure animal charcoal.

"The pressed bark is now boiled in acid and water, and this for the first time dissolves the quina. This is precipitated by soda, and thus the pure quina is formed. On treating with acid. sulph., the hospital sulphate of quinine crystallizes at once. You now therefore see by this sketch that no impurity can exist, and the action of the caustic soda on the bark sufficiently bleaches the quina without the aid of charcoal. The treatment of the soda liquor is rather a troublesome operation, but all of which will appear in the patent."—*Extract of a letter.*

I have found Mr. Herring's hospital sulphate of quinine to be a good article, containing within a few per cents. as much base as the whitest in the market.

QUINTESSENCE. The alchemists understood by this term, now no longer in scientific use, the solution in alcohol of the principles which this menstruum can extract from aromatic plants or flowers, by digestion, during some days, in the sun, a stove, or upon a sand-bath slightly warmed. A quintessence, therefore, corresponds to the alcoholic tincture or essence (not essential oil) of the present day. See **PERFUMERY.**

R.

RAILWAY TRAIN BREAK. Patent break for railway trains, designed to obviate the serious defects of the common railway break. The first advantage which it presents is an improvement as to the permanent way, which is effected by the use of the long shoe, by having 18 inches of clearing surface upon the rails; it will slide over the soft or bad places hitherto made worse by the application of the ordinary break, the wheels having only about one inch of surface. The ends of the rails will not be jumped up, or flattened by the wheels coming in contact with them, which is now the case, as the wheels, resting upon the shoe, will, in fact, press such irregularities down.

The second advantage is that in the locomotive department, the wheels' tires are always preserved perfectly circular, and the shoe, by bearing up the wheel when the break is applied, prevents the flat places being formed, and also torsion upon the axles. The wheels, whether of wood or iron, are saved from being strained, and the tires, rivets, bolts, &c. are not liable to get loose, an evil which is caused by their becoming heated. The carriage frame is also saved from being racked and twisted, as the patent break is suspended from the axle only. This will cause a great saving in the repair of break carriages. By the adoption of this break a power is gained, when applied to 2 wheels only, fully equal to the usual breaks applied to 6, a feature of no slight importance in cases of danger. This power in retarding a train is also always the same, which is not the case with the common break. The different weights with which the carriages are loaded are continually altering the position of the blocks, which varies the number of turns of the screw necessary to apply the ordinary break; while in wet, greasy weather, it is almost impossible to skid the wheels. The patent break can be applied in less time and with 2 or 3 turns only of the screw, whereas 6 or 7 turns are required with that hitherto in use. It is also free from the usual unpleasant noise, smell, and sensation from friction.

Lastly, considerable saving is effected both in the amount of stock required and in the wear and tear of railway apparatus.—*Montgomery's patent.*

The necessity for the introduction of an improved railway break is universally admitted by all engineers and practical men. The breaks in common use are very injurious, both with regard to the durability of the wheels and rails. Timber blocks of poplar

wood are made to bear hard upon the peripherics of the wheels, so as to stop their revolution. The result is the grinding of many flat places on the tire of the wheels and the abrasion of the rails, occasioning frequent renewal.

RAISINS, are grapes allowed to ripen and dry upon the vine. The best come from the south of Europe, as from Roquevaire in Provence, Calabria, Spain and Portugal. Fine raisins are also imported from Smyrna, Damascus, and Egypt. Sweet fleshy grapes are selected for maturing into raisins, and such as grow upon the sunny slopes of hills sheltered from the north winds. The bunches are pruned, and the vine is stripped of its leaves, when the fruit has become ripe; the sun then beaming full upon the grapes completes their saccharification, and expels the superfluous water. The raisins are plucked, cleansed, and dipped for a few seconds in a boiling lye of wood ashes and quicklime, at 12 or 13 degrees of Beaumé's areometer. The wrinkled fruit is lastly drained, dried and exposed in the sun upon hurdles of basket-work during 14 or 15 days.

The finest raisins are those of the sun, so called; being the plumpest bunches, which are left to ripen fully upon the vine, after their stalks have been half cut through.

The amount of raisins imported for home consumption was in the year 1850, 218,982 cwts.; in 1851, 208,801 cwts.; duty received, 1850, 172,260*l.*; 1851, 164,401*l.*

RAM HYDRAULIC. Originally invented by Montgolfier, in France, and patented by him in 1797.

This machine, which is self-acting, is composed of an air vessel and 3 valves, 2 for the water and 1 for keeping up the supply of air. Upon pressing down the valve in the conducting tube, which opens downwards, the water escapes from it, until this momentum is sufficient to overcome the weight, when the valve immediately rises and closes the aperture. The water, having then no other outlet than the inner valve, rushes through it by its general force, compressing the air in the air vessel until equilibrium takes place, when the air recoils by its expansive force, closing the inner valve, which retains the water above it, and driving it up the ascending tube. By this reaction the water is forced back along the conducting pipe, producing a partial vacuum beneath the outer valve, which immediately falls by its own weight. The water thus escapes until it has acquired sufficient force to close this, when the action proceeds as before. It is best adapted for raising moderate quantities of water, as for household or farming purposes.

RAPE-SEED, imported for home consumption in 1850, 107,029 qrs.; in 1851, 82,394 qrs. See OILS, UNCRUOUS.

RASP, MECHANICAL, is the name given by the French to an important machine much used for mashing beet-roots. See SUGAR.

RASPS AND FILES. File-making is a manufacture which is still in a great measure confined to Sheffield. It is remarkable that hitherto no machine has been constructed capable of producing files which rival those cut by the human hand. Machine-made files have not the "bite" which hand-cut files have: this is accounted for by the peculiar facilities of the human wrist to accommodate itself to the particular angle suitable to produce the proper "cut." "Small files are made out of the best cast steel; those of a larger size from ordinary steel; flat files are forged on an ordinary study. Other forms on bolsters, with the indentature corresponding to the shape required being thereon impressed, a chisel wider than the blank to be cut is used as the only instrument to form the teeth: it is moved by the hand with the greatest nicety. After cutting and previous to hardening, the file is immersed in some adhesive substance, such as ale-grounds, in which salt has been dissolved; this protects the teeth from the direct action of the fire; it is then immersed perpendicularly in water; cleansed by finishing.

RATAFIA, is the generic name, in France, of *liqueurs* compounded with alcohol, sugar, and the odoriferous or flavouring principles of vegetables. Bruised cherries with their stones are infused in spirit of wine to make the ratafia of Grenoble de *Teysseire*. The liquor being boiled and filtered, is flavoured, when cold, with spirit of *noyons*, made by distilling water off the bruised bitter kernels of apricots, and mixing it with alcohol. Syrup of bay laurel and galango are also added. See LIQUEURS.

RAZORS. 151. Elliot, J. Townhead Street, Sheffield—Manufacturer. Pattern razors manufactured of the best steel, exhibited for temper, design and workmanship.

Frame-back razor, ground exceedingly thin and cannot require to be again ground, thus retaining a fine and durable edge, and increasing greatly the ease of shaving. The gold, silver, steel, german-silver or brass backs, form an elegant contrast to the blade, and enhance the beauty of appearance, as well as afford more opportunity for originality of design and skill in execution.

Two workmen are always engaged in razor-making. The rod of steel of which they are made is about half an inch in breadth, and of sufficient thickness to form the back. The stake upon which they are forged is rounded on both sides of the top, which is instrumental in thinning the edge, and much facilitates the operation of grinding. The blades are then hardened and tempered in the ordinary way, with the exception that

they are placed on their back on an iron plate, and the moment they assume a straw colour of a deep shade they are removed.

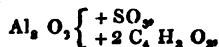
The grinding follows, on a stone revolving in water; then glazing on a wooden disc. The fine polish is given by a wooden wheel, having its circumference covered with buff leather, which is covered with crocus. The ornamentation of the blade by etching with acid and gilding, if such is required, is the last process.

REALGAR, Red Orpiment. (*Arsenic sulphure, Fr. ; Rother schwefelarsenik, Germ.*) This ore occurs in primitive mountains, associated sometimes with native arsenic under the form of veins, efflorescences, very rarely crystalline; as also in volcanic districts; for example, at Solfaterra near Naples; or sublimed in the shape of stalactites, in the rents and craters of Etna, Vesuvius, and other volcanoes. Its spec. grav. varies from 3.3 to 3.6. It has a fine scarlet colour in mass, but orange red in powder, whereby it is distinguishable from cinnabar. It is soft, sectile, readily scratched by the nail; its fracture is vitreous and conchoidal. It volatilizes easily before the blowpipe, emitting the garlic smell of arsenic, along with that of burning sulphur. It consists of arsenic 70, sulphur 30 in 100 parts. It is employed sometimes as a pigment. Factitious orpiment is made by distilling in an earthen retort a mixture of sulphur and arsenic, of orpiment and sulphur, or of arsenious acid, sulphur and charcoal. It has not the rich colour of the native pigment, and is much more poisonous; since, like factitious orpiment, it always contains more or less arsenious acid.

RECTIFICATION, is a second distillation of alcoholic liquors, to free them from whatever impurities may have passed over in the first.

RED LIQUOR, is a crude acetate of alumina, employed in calico-printing, and prepared from pyrolignous acid; which see, and **CALICO PRINTING**.

At first sight it would appear that alumina is the intermediate fixing agent. The pyrolignite of alumina, by its easy decomposition into acetic acid and alumina, would be the one preferred; but practice has shown that a sulpho-acetate of alumina gives the best results, and which is composed as follows:—



and prepared by mixing together

453 lbs. of ammoniacal alum.

379 lbs. of acetate of lead, or 315 lbs. of pyrolignite of lead.

1132 lbs. of water.

or,

383 lbs. of sulphate of alumina.

379 lbs. of acetate of lead, or 315 lbs. of pyrolignite of lead.

1132 lbs. of water.

or,

453 lbs. of alum, and a quantity of solution of pyrolignite of lime, amounting to 158 lbs.

or,

333 lbs. of sulphate of alumina, with the same amount of pyrolignite of lime.

These substances are well stirred together for several hours, complete double decomposition ensues, sulphate of lead is deposited, and sulpho-acetate of alumina remains in solution with one equivalent of sulphate of ammonia, proceeding from the ammoniacal alum employed, as only two equivalents of sulphuric acid are removed from the four which alum contains.

But as sulphate of ammonia is of no use in the process of mordanting cloth, and as it may be considered as increasing the price of the articles to the manufacturer, a very intelligent firm had the good idea of replacing ammoniacal alum by sulphate of alumina, thus not only rendering the liquor cheaper, but their liquor marks the same strength as that of other manufacturers,—namely, sp. gr. 1.085, or 17 Twaddle. The red mordant D of this firm contains a larger amount of useful agents under the same bulk of fluid.

The following analyses clearly show this point: (see next page)—

From these results it is easy to perceive that the composition of red liquors varies a great deal in Manchester, and that it is of importance to our extensive calico-printing firms to inquire more than they at present do into the composition of their red mordants. By doing so we have no doubt they will arrive at two ends,—viz., account better than they do for the superiority of some prints over others, and discover why certain persons always believe the peculiar red mordant they employ the best, and if results do not come up, attribute failures to the madder, &c.

I may mention here a fraud or two which has been discovered in the pyrolignite of iron, or black liquor, employed by calico printers and dyers for obtaining black, grey,

Composition of Four Mordants per Gallon.

| Substances. | Formula. Al ₂ O ₃ SO ₃ QCl, H ₂ O ₃ +NH ₃ SO ₃ HO. | | | | | | Formula. Al ₂ O ₃ QSO ₃ C ₁ H ₃ O ₃ +NH ₃ SO ₃ HO. | | | Formula. Al ₂ O ₃ +SO ₃ QCl, H ₃ O ₃ . | | |
|--------------------|---|-----|------|------------|-----|------|---|-----|------|---|-----|------|
| | Mordant A. | | | Mordant B. | | | Mordant C. | | | Mordant D. | | |
| | grains. | oz. | grs. | grains. | oz. | grs. | grains. | oz. | grs. | grains. | oz. | grs. |
| Alumina - - - | 1690·0 | 3 | 18 | 1830 0 | 4 | 19 | 1239·0 | 2 | 365 | 2164·4 | 4 | 416 |
| Sulphuric acid - - | 1642·5 | 6 | 20 | 2800·0 | 6 | 178 | 3017·0 | 6 | 395 | 1664·6 | 3 | 3·3 |
| Acetic acid - - - | 3369·8 | 7 | 307 | 3370·0 | 8 | 70 | 1281·7 | 2 | 401 | 3679·2 | 8 | 179 |
| Ammonia and water | ·674·1 | 1 | 236 | ·910·0 | 2 | 35 | ·653·1 | 1 | 215 | | | |

maroon, chocolate, &c. It is but just to state that this fraud is mainly owing to the dyers and calico printers themselves, who require articles at a lower price than they can be produced at.

The products added into some black liquors are muriate or sulphate of iron, in proportions varying from 10 to 30 per cent. To detect them the black liquor is treated by carbonate of soda, which, on throwing down the oxide of iron, produces chloride of sodium and sulphate of soda. The whole is then thrown upon a filter. The liquor, when evaporated to dryness, and calcined, to destroy organic matter, leaves a residue, which, on being dissolved, gives, after being rendered acid with nitric acid, a white curdy precipitate with nitrate of silver, and a white pulverulent one with nitrate of baryta, if chlorides or sulphates are present in the liquor.

REED, is the well-known implement of the weaver, made of parallel slips of metal or reeds, called dents. A thorough knowledge of the adaptation of yarn of a proper degree of fineness to any given measure of reed, constitutes one of the principal objects of the manufacturer of cloths; as upon this depends entirely the appearance, and in a great degree the durability, of the cloth when finished. The art of performing this properly is known by the names of *examining*, *setting*, or *slaying*, which are used indiscriminately, and mean exactly the same thing. The reed consists of two parallel pieces of wood, set a few inches apart, and they are of any given length, as a yard, a yard and a quarter, &c. The division of the yard being into halves, quarters, eighths, and sixteenths; the breadth of a web is generally expressed by a vulgar fraction, as $\frac{1}{2}$, $\frac{3}{4}$, $\frac{5}{8}$, $\frac{3}{4}$; and the subdivisions by the eighths or sixteenths, or *nails*, as they are usually called, as $\frac{1}{8}$, $\frac{3}{8}$, $\frac{1}{4}$, &c., or $\frac{1}{16}$, $\frac{3}{16}$, $\frac{1}{8}$, &c. In Scotland, the splits of cane which pass between the longitudinal pieces or ribs of the reed are expressed by hundreds, porters, and splits. The porter is 20 splits or $\frac{1}{4}$ th of an hundred.

In Lancashire and Cheshire a different mode is adopted, both as to the measure and divisions of the reed. The Manchester and Bolton reeds are counted by the number of splits, or, as they are there called, dents, contained in 24 $\frac{1}{2}$ inches of the reed. These dents, instead of being arranged in hundreds, porters, and splits, as in Scotland, are calculated by what is there termed *hares* or *bears*, each containing 20 dents, or the same number as the porter in the Scotch reeds. The Cheshire or Stockport reeds, again, receive their designation from the number of ends or threads contained in one inch, two ends being allowed for every *dent*, that being the almost universal number in every species and description of plain cloth, according to the modern practice of weaving, and also for a great proportion of fanciful articles.

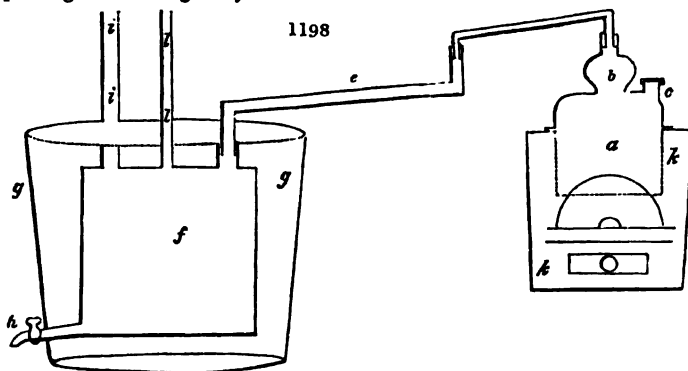
The number of threads in the warp of a web is generally ascertained with considerable precision by means of a small magnifying glass, fitted into a socket of brass, under which is drilled a small round hole in the bottom plate of the standard. The number of threads visible in this perforation ascertains the number of threads in the standard measure of the reed. Those used in Scotland have sometimes four perforations, over any one of which the glass may be shifted. The first perforation is $\frac{1}{2}$ of an inch in diameter, and is therefore well adapted to the Stockport mode of counting; that is to say, for ascertaining the number of ends or threads per inch; the second is adapted for the Holland reed, being $\frac{3}{80}$ th part of 40 inches; the third is $\frac{1}{700}$ th of 37 inches, and is adapted for the now almost universal construction of Scotch reeds; and the fourth, being $\frac{1}{300}$ th of 34 inches, is intended for the French cambrics. Every thread appearing in these respective measures, of course represents 200 threads, or 100 splits, in the standard breadth; and thus the quality of the fabric may be ascertained with considerable precision, even after the cloth has undergone repeated wettings, either at the bleaching-ground or dye-work. By counting the other way, the proportion which the woof bears to the warp is also known, and this forms the chief use of the glass to the manufacturer and operative weaver, both of whom are previously acquainted with the exact measure of the reed.

Comparative TABLE of 37-inch reeds, being the standard used throughout Europe, for linsens, with the Lancashire and Cheshire reeds, and the foreign reeds used for holland and cambric.

| Scotch. | Lancashire. | Cheshire. | Dutch holland. | French cambric. |
|---------|-------------|-----------|----------------|-----------------|
| 600 | 20 | 34 | 550 | 653 |
| 700 | 24 | 38 | 650 | 761 |
| 800 | 26 | 44 | 740 | 870 |
| 900 | 30 | 50 | 832 | 979 |
| 1000 | 34 | 54 | 925 | 1089 |
| 1100 | 36 | 60 | 1014 | 1197 |
| 1200 | 40 | 64 | 1110 | 1300 |
| 1300 | 42 | 70 | 1202 | 1414 |
| 1400 | 46 | 76 | 1295 | 1464 |
| 1500 | 50 | 80 | 1387 | 1602 |
| 1600 | 52 | 86 | 1480 | 1752 |
| 1700 | 56 | 92 | 1571 | 1820 |
| 1800 | 58 | 96 | 1665 | 1958 |
| 1900 | 62 | 104 | 1757 | 2067 |
| 2000 | 66 | 110 | 1850 | 2176 |

In the above table, the 37-inch is placed first. It is called Scotch, not because it either originated or is exclusively used in that country. It is the general linen reed of all Europe; but in Scotland it has also been adopted as the regulator of her cotton manufactures.

REFINING OF GOLD AND SILVER; called also *Parting*. (*Affinage d'argent*, *Départ*, Fr.; *Scheidung in die quart*, Germ.) For several uses in the arts, these precious metals are required in an absolutely pure state, in which alone they possess their malleability and peculiar properties in the most eminent degree. Thus, for example, neither gold nor silver leaf can be made of the requisite fineness, if the metals contain the smallest portion of copper alloy. Till within these twenty years, the parting of silver from gold was effected everywhere by nitric acid; it is still done so in all the establishments of this country, except the Royal Mint; and in the small refining-houses abroad. The following apparatus may be advantageously employed in this operation. It will serve the double purpose of manufacturing nitric acid of the utmost purity, and of separating silver from gold by its means.



1. On procuring nitric acid for parting. — *a* is a platinum retort or alembic; *b* is its capital, terminating above in a tubulure, to which a kneed tube of platinum, about 2 feet long, is adapted; *c* is the tubulure of the retort, for supplying acid during the process, and for inspecting its progress. It is furnished with a lid ground air-tight, which may be secured in its place by a weight. *e* is a stoneware pipe, about two inches diameter, and several feet long, according to the locality in which the operation is to be carried on. It is made in lengths fitted to one another, and secured at the joints with loam-lute. The one bend of this earthenware hard salt-glazed pipe is adapted to receive the platinum tube, and the other bend is inserted into a tubulure in the top of the stoneware drum *f*. The opening *l, l*, in the middle of the top of *f*, is

for inspecting the progress of the condensation of acid; and the third tubulure terminates in a prolonged pipe *i*, *i*, consisting of several pieces, each of which enters from above conically into the one below. The joinings of the upper pieces need not be tightly luted, as it is desirable that some atmospherical oxygen should enter, to convert the relatively light nitrous gas into nitrous or nitric acid vapour, which when supplied with moisture will condense and fall down in a liquid state. To supply this moisture in the most diffusive form, the upright stoneware pipes *i*, *i*, *l*, *l*, (at least 3 inches diameter, and 12 feet high,) should be obstructed partially with flint nodules, or with siliceous pebbles; and water should be allowed to trickle upon the top pebble from a cistern placed above. Care must be taken to let the water drop so slowly as merely to preserve the pebbles in a state of humidity. *A* is a stopcock, of glass or stoneware, for drawing off the acid from the cistern *f*. *A* is a section of a small air-furnace, covered in at top with an iron ring, on which the flat iron ring of the platinum frame rests.

g, *g*, is a tub in which the stoneware cistern stands, surrounded with water, kept constantly as cold as possible by passing a stream through it; the spring water entering by a pipe that dips near to the bottom, and the hot water escaping at the upper edge.

With the above apparatus, the manufacture of pure nitric acid is comparatively easy and economical. Into the alembic *a*, 100 pounds (or thereby) of pure nitre, coarsely bruised if the crystals be large, are to be put; the capital is then to be adapted, and the platinum tube (the only movable one) luted into its place. Twenty pounds of strong sulphuric acid are now to be introduced by the tubulure *c*, and then its lid must be put on. No heat must yet be applied to the alembic. In about an hour, another ten pounds of acid may be poured in, and so every hour, till 60 pounds of acid have been added. A few hours after the affusion of the last portion of acid, a slight fire may be kindled in the furnace *k*.

By judicious regulation of the heat, the whole acid may be drawn off in 24 hours; its final expulsion being aided by the dexterous introduction of a quart or two of boiling water, in small successive portions, by the tubulure *e*, whose lid must be instantly shut after every inspersion. The most convenient strength of acid for the parting process, is when its specific gravity is about 1.320, or when a vessel that contains 16 ounces of pure water, will contain 21½ of the aquafortis. To this strength it should be brought very exactly by the aid of a hydrometer.

Its purity is easily ascertained by letting fall into it a few drops of solution of silver; and if no perceptible milkiness ensues, it may be accounted good. Should a white cloud appear, a few particles of silver may be introduced, to separate whatever muriatic acid may be present, in the form of chloride of silver. Though a minute quantity of sulphuric acid should exist in the nitric, it will be of no consequence in the operation of parting.

2. *On parting by the nitric acid, called by the Mexicans, "Il apartado."*—The principle on which this process is founded, is the fact of silver being soluble in nitric acid, while gold is insoluble in that menstruum. If the proportion of gold to that of silver be greater than one to two, then the particles of the former metal so protect or envelop those of the latter, that the nitric acid, even at a boiling heat, remains quite inactive on the alloy. It is indispensable, therefore, that the weight of the silver be at least double that of the gold. 100 pounds of silver take 38 pounds of nitric acid, of specific gravity 1.320, for oxidizement, and 111 for solution of the oxide; being together 149; but the refiner often consumes, in acid of the above strength, more than double the weight of silver, which shows great waste, owing to the imperfect means of condensation employed for recovering the vapours of the boiling and very volatile acid.

By the apparatus above delineated, the 38 pounds of acid expended in oxidizing the silver, become nitrous gas in the first place, and are afterwards reconverted in a great measure into nitric acid by absorption of atmospherical oxygen; so that not one-fifth need be lost, under good management. As the acid must be boiled on the granulated *garble*, or alloy, to effect the solution of the silver, by proper arrangements the vapours may be entirely condensed, and nearly the whole acid be recovered, except the 111 parts indispensable to constitute nitrate of silver. Hence, with economical management, 120 pounds of such acid may be assigned as adequate to dissolve 100 of silver associated with 50 of gold.

It must here be particularly observed, that 100 pounds of copper require 130 pounds of the above acid for oxidizement; and 390 for solution of the oxide; being 520 pounds in whole, of which less than ¼ part could be recovered by the above apparatus. It is therefore manifest that it is desirable to employ silver pretty well freed from copper by a previous process; and always, if practicable, a silver containing some gold.

These data being assumed as the bases of the parting operation, 60 pounds of gold and silver alloy or *garble* finely granulated, containing not less than 40 pounds of silver, are to be introduced into the ten-gallon alembic of platinum, *fig.* 1198., and 80 pounds of nitric acid, of 1.320, is to be poured over the alloy; a quantity which will measure 6 gallons imperial. As for the bulk of the alloy, it is considerably less than half a gallon. Abun-

dance of space therefore remains in the alembic for effervescence and ebullition, provided the fire be rightly tempered.

By the extent of stoneware conducting pipe *e*, which should not be less than 40 feet, by the dimensions and coldness of the cistern *f*, and by the regenerating influence of the vertical aerial pipe filled with moist pebbles *i, i*, it is clear, that out of the 80 pounds of nitric acid, specific gravity 1.320, introduced at first, from 20 to 30 will be recovered.

Whenever the effervescence and disengagement of nitrous red fumes no longer appear on opening the orifice *c*, the fire must be removed, and the vessel may be cooled by the application of moist cloths. The alembic may be then disengaged from the platinum tube, and lifted out of its seat. Its liquid contents must be cautiously decanted off, through the orifice *e*, into a tub nearly filled with soft water. On the heavy pulverulent gold which remains in the vessel, some more acid should be boiled, to carry off any residuary silver. This metallic powder, after being well washed with water, is to be dried, fused along with a little nitre or borax, and cast into ingots.

Plates of copper being immersed in the nitric solution contained in wooden or stoneware cisterns, will throw metallic silver down, while a solution of nitrate of copper, called blue water, will float above. The pasty silver precipitate is to be freed from the nitrate of copper, first, by washing with soft water, and next, by strong hydraulic pressure in cast-iron cylinders. The condensed mass, when now melted in a crucible along with a little nitre and borax, is fine silver.

The above apparatus has the further advantage of enabling the operator to recover a great portion of his nitric acid, by evaporating the blue water to a state approaching to dryness, with the orifices at *e*, and at the top of the capital, open. In the progress of this evaporation, nothing but aqueous vapour escapes. Whenever the whole liquid is dissipated, the pipe *d* is to be re-adjusted, and the lid applied closely to *c*. The heat being now continued, and gradually increased, the whole nitric acid will be expelled from the copper oxide, which will remain in a black mass at the bottom of the alembic. The contrivance for letting water trickle upon the pebbles, must be carefully kept in play, otherwise much of the evolved acid would be dissipated in nitrous fumes. With due attention to the regenerative plan, a great part of the acid may be recovered, at no expense but that of a little fuel.

The black oxide of copper thus obtained, is an economical form of employing that metal for the production of the sulphate; 100 pounds of it, with 122½ of sulphuric acid diluted with water, produce 312½ pounds of crystallized sulphate of copper. A leaden boiler is best adapted for that operation. 100 pounds of silver are precipitable from its solution in nitric acid, by 29 of copper. If more be needed, it is a proof that a wasteful excess of acid has existed in the solution.

In parting by nitric acid, the gold generally retains a little silver; as is proved by the cloud of chloride of silver which it affords, at the end of some hours, when dissolved in aqua regia. And on the other hand, the silver retains a little gold. These facts induced M. Dixé, when he was inspector of the French mint, to adopt some other process, which would give more accurate analytical results; and after numerous experiments, he ascertained that sulphuric acid presented great advantages in this point of view, since with it he succeeded in detecting, in silver, quantities of gold which had eluded the other plan of parting. The suggestion of M. Dixé has been since universally adopted in France. Mr. Costell, about twenty years ago, erected in Pomeroy-street, Old Kent-road, a laboratory upon the French plan, for parting by sulphuric acid; but he was not successful in his enterprise; and since he relinquished his business, Mr. Matheson introduced the same system into our Royal Mint, under the management of Mr. Costell's French operatives. In the Parisian refineries, gold, to the amount of a two-thousandth part of the weight, has been extracted from all the silver which had been previously parted by the nitric acid process; being 3500 francs in value upon every thousand kilogrammes of silver.

I shall give first a general outline of the method of parting by sulphuric acid, and then describe its details as I have lately seen them executed upon a magnificent scale in an establishment near Paris.

The most suitable alloy for refining gold, by the sulphuric-acid process, is the compound of gold, silver, and copper, having a standard quality, by the cupel, of from 900 to 950 millièmes, and containing one-fifth of its weight of gold. The best proportions of the three metals are the following: — silver, 725; gold, 200; copper, 75; = 1000. It has been found that alloys which contain more copper, afford solutions that hold some anhydrous sulphate of that metal in solution, which prevents the gold from being readily separated; and that alloys containing more gold, are not acted on easily by the sulphuric acid. The refiner ought, therefore, when at all convenient, to reduce the alloys that he has to treat, to the above-stated proportions. He may effect this purpose either by fusing the coarser alloys with nitre in a crucible, or by adding finer alloy, or even fine silver, or finally, by subjecting the coarser alloys to a previous cupellation with lead on

the great scale. As to gold or silver bullion, which contains lead and other easily oxidizable metals besides copper, the refiner ought always to avoid treating them by sulphuric acid; and should separate, first of all, these foreign metals by the agency of nitre, if they exist in minute quantity; but if in larger, he should have recourse to the cupel. Great advantage will therefore be derived from the judicious preparation of the alloy to be refined.

For an alloy of the above description, the principal Parisian refiners are in the habit of employing thrice its weight of sulphuric acid, in order to obtain a clear solution of sulphate of silver, which does not too suddenly concrete on cooling, so as to obstruct its discharge from the alembic by decantation. A small increase in the quantity of copper, calls for a considerable increase in the quantity of acid.

Generally speaking, one-half of the sulphuric acid strictly required for converting the silver and copper into sulphates, is decomposed into sulphurous acid, which is lost to the manufacturer, unless he has recourse to the agency of nitrous acid.

The process for silver containing but little gold, consists of five different operations.

1. Upon several furnaces, one foot in diameter, egg-shaped alembics of platinum are mounted, into each of which are put 3 kilogrammes (8 lbs. troy) of the granulated silver, containing a few grains of gold per pound, and 6 kilogrammes of concentrated sulphuric acid. The alembics are covered with conical capitals, ending in bent tubes, which conduct the acid vapours into lead pipes of condensation; and the furnaces are erected under a proper hood. As the cold acid is inoperative, it must be set a boiling, at which temperature it gives up one atom of its oxygen to the metal, and is transformed into sulphurous acid, which escapes in a gaseous state. Some of the undecomposed sulphuric acid immediately combines with the oxide into a sulphate, which subsides, in the state of a crystalline powder, to the bottom of the vessel. The solution goes on vigorously, with a copious disengagement of sulphurous acid gas, only during the two or three first hours; after which it proceeds slowly, and is not completed till after a digestion of nearly twelve hours more. During the ebullition a considerable quantity of sulphuric acid vapour escapes along with the sulphurous acid gas; the former of which is readily condensed in a large leaden receiver immersed in a cistern of cold water, if need be. It has been proposed to condense the sulphurous acid, by leading it over extensive surfaces of lime-pap, as in the coal-gas purifiers.

2. When the whole silver has been converted into sulphate, this is to be emptied out of the alembic into water contained in a round-bottomed receiver lined with lead, and diluted till the density of the solution marks from 15° to 20° Baumé. The small portion of gold, in the form of a brown powder, which remains undissolved, having been allowed to settle to the bottom, the supernatant solution of silver is to be decanted carefully off into a leaden cistern, and the powder being repeatedly edulcorated with water, the washings are to be added to it. The silver is now to be precipitated by plunging plates of copper in the solution, and the magma which falls is to be well washed, and freed from the residuary particles of sulphate of copper by powerful compression.

3. The silver, precipitated and dried as above described, is melted in a crucible, and cast into an ingot.

4. The gold powder is also dried and cast into an ingot, a little nitre being added in the fusion, to oxidize and separate any minute particles of copper that may perchance have been protected from the solvent action of the acid.

5. As the sulphate of copper is of considerable value, its solution is to be neutralized, evaporated in leaden pans to a proper strength, and set aside to crystallize in leaden cisterns. The farmers throughout France consume an immense quantity of this salt. They sprinkle a weak solution of it (at 2° or 3° Baumé) over their grain before sowing it, in order to protect it against the ravages of birds and insects.

The pure gold, at the instant of its separation from the alloy by the action of sulphuric acid, being in a very fine powder, and lying in close contact with the platinum, under the influence of a boiling menstruum, which brightens the surfaces of the two metals, and raises their temperature to fully the 600th degree of Fahrenheit's scale, tends to become partially soldered to the platinum, and may thus progressively thicken the bottom of the still. The importance of preserving this vessel entire, and of economizing the fuel requisite to heat its contents, induces the refiner to detach the crust of gold from time to time, by passing over the bottom of the still, in small quantities, a dilute nitromuriatic acid, which acts readily on gold, but not on platinum. But as this operation is a very delicate one, it must be conducted with great circumspection. The danger of such adhering deposits is much increased by using too high a heat, and too small a body of acid, relatively to the metals dissolved. Hence it is advantageous to employ alembics of large size. Should any lead or tin get into the platinum still, while the hot acid is in it, the precious vessel would be speedily destroyed; an accident which has not unfrequently happened. Each operation may be conveniently finished in twelve hours

so that each alembic may refine with ease 160 marcs daily. Some persons work more rapidly, but such haste is hazardous.

The Parisian refiners restore to the owners the whole of the gold and silver contained in the ingots, reserving to themselves the copper which formed the alloy, and charging only the sum of 5½ francs per kilogramme (2·68 lbs. troy) for the expense of the parting of the metals.

If they are employed to refine an ingot of silver containing less than one-tenth of gold, they retain for themselves a two-thousandth part of the gold, and all the copper, existing in the alloy; return all the rest of the gold, with the whole of the silver, in the ingot; and give, besides, to the owners a *premium* or *bonus*, which amounted lately to $\frac{1}{2}$ of a franc on the kilogramme of metal. Should the owner desire to have the whole of the gold and silver contained in his ingot, the refiner then demands from him 2 francs and 68 centimes per kilogramme, retaining the copper of the alloy. As to silver ingots of low standard, the perfection of the refining processes is such, that the mere copper contained in them pays all the costs; for in this case, the refiner restores to the proprietor of the ingot as much fine silver as the assay indicated to exist in the ingot, contenting himself with the copper of the alloy. See *infra*.

The chemical works of M. Poizat, called *affinage d'argent*, on the bank of the canal de l'Ouercq, in the vicinity of Paris, are undoubtedly the most spacious and best arranged for refining the precious metals, which exist in the world. On being introduced to this gentleman, by my friend and companion M. Clement-Desormes, he immediately expressed his readiness to conduct me through his *fabrique*, politely alluding to the French translation of my Dictionary of Chemistry, which lay upon the desk of his *bureau*. The principal room is 240 feet long, 40 feet wide, and about 30 feet high. A lofty chimney rises up through the middle of the apartment, and another at each of its ends. The one space, 120 feet long, to the right of the central chimney, is allotted to the processes of dissolving the silver, and parting the gold; the other, to the left, to the evaporation and crystallization of the sulphate of copper, and the concentration of the recovered sulphuric acid.

M. Poizat melts his great masses of silver in pots made of malleable iron, capable of holding several cwts. each; and granulates it by pouring it into water contained in large iron pans. The granulated silver is dried with heat, and carried into a well lighted office enclosed by glazed casements, to be weighed, registered, and divided into determinate portions. Each of these is put into a cast-iron pot, of a flattened hemispherical shape, about 2 feet in diameter, covered with an iron lid, made in halves, and hinged together in the middle line. From the top of the fixed lid a bent pipe issues, and proceeds downwards into an oblong leaden chest sunk beneath the floor. Four of the above cast-iron pots stand in a line across the room, divided into two ranges, with an intervening space for passing between them. The bottoms of the pots are directly heated by the flame, one fire serving for two pots. Two parts of concentrated sulphuric acid by weight are poured upon every part of granulated silver, and kept gently boiling till the whole silver be converted into a pasty sulphate.

From the underground leaden chests, a leaden pipe, 4 inches in diameter, rises vertically, and enters the side of a leaden chamber, which is supported upon strong cross-beams or rafters, a little way beneath the roof of the apartment. This chamber, which is 90 feet long, 10 feet wide, and 6 feet high, is intended to condense the sulphuric acid vapours, along with some of the sulphurous acid; that of the latter being promoted by the admission of nitrous gas and air, which convert it into sulphuric acid. From the further end of this chamber, a large square leaden pipe returns with a slight slope towards the middle of the room, and terminates at the right-hand side of the central chimney, in a small leaden chest, for receiving the drops of acid which are condensed in the pipe. From that chest a pipe issues, to discharge into the high central chimney the incondensable gases, and also to maintain a constant draught through the whole series of leaden chambers back to the cast-iron hemispherical pots.

Besides the above cast-iron pots, destined to dissolve only the coarse cupreous silver, containing a few grains of gold per pound, there are, in the centre of the apartment, at the right-hand side of the chimney, 6 alembics of platinum, in which the rich alloys of gold and silver are treated in the process of refining gold.

The pasty sulphate of silver obtained in the iron pots, is transferred by cast-iron ladles with long handles into large leaden cisterns, adjoining the pots, and there diluted with a little water to the density of 36° Baumé. Into this liquor, steam is admitted through a series of upright leaden pipes arranged along the side of the cistern, which speedily causes ebullition, and dilutes the solution eventually to the 22d degree of Baumé. In this state, the liquid supersulphate is run off by leaden syphons into large oblong leaden cisterns, rounded at the bottom; and is there exposed to the action of ribands of copper, like thin wood shavings. The metallic silver precipitates in a pasty form; and the

supernatant sulphate of copper is then run off into a cistern, upon a somewhat lower level, where it is left to settle and become clear.

The precipitate of silver, called by the English, water-silver, and by the French, *chaux d'argent*, is drained, then strongly squeezed in a square box of cast iron, by the action of a hydraulic press; in which 60 pounds of silver are operated upon at once.

The silver lumps are dried, melted in black lead crucibles, in a furnace built near the silver end of the room, where the superintendent sits in his *bureau* — a closet enclosed by glazed casements, like a green-house. The whole course of the operations is so planned, that they are made to commence near the centre with the mixed metals, and progressively approach towards the office end of the apartment as the parting processes advance. Here the raw material, after being granulated and weighed, was given out, and here the pure gold and silver are finally eliminated in a separate state.

In the other half of the hall, the solutions of sulphate of copper are evaporated in large shallow leaden pans, placed over a range of furnaces; from which, at the proper degree of concentration, they are run off by syphons into crystallizing pans of the same metal. From the mother-waters, duly evaporated, a second crop of crystals is obtained; and also a third, the last being anhydrous, from the great affinity for water possessed by the strong sulphuric acid with which they are now surrounded. The acid in this way parts with almost the whole of the cupreous oxide, and is then transferred into a large alembic of platinum (value 1000*l.*), to be rendered fit, by re-concentration, for acting upon fresh portions of granulated silver. The capital of that alembic is connected with a leaden worm, which traverses an oblong vessel, through which a stream of cold water flows.

The crystallized sulphate of copper fetched, some years ago, 30*l.* a ton. It is almost all sold to the grocers in the towns of the agricultural districts of France. In the above establishment of M. Poizat, silver to the value of 10,000*l.* can be operated upon daily.

There is a steam engine of 6-horse power placed in a small glazed chamber at one side of the parting hall, which serves to work all his leaden pumps for lifting the dilute sulphuric acid and acidulous solutions of copper into their appropriate cisterns of concentration, as also to grind his old crucibles, and drive his amalgamation mill, consisting of a pair of vertical round-edged wheels, working upon one shaft, in a groove formed round a central hemisphere — of cast iron. After the mercury has dissolved out of the ground crucibles all the particles of silver which it can find, the residuary earthy matter is sold to the *sweep-washers*. The floor of the hall around the alembics, pots, and cisterns, is covered with an iron grating, made of bars having one of their angles uppermost, to act as scrapers upon the shoes of the operatives. The dust collects in a vacant space left beneath the grating, whence it is taken to the amalgamation mill. The processes are so well arranged and conducted by M. Poizat, that he can execute as much business in his establishment with 10 workmen as is elsewhere done with from 40 to 50; and with less than 3 grains of gold, in one Paris pound or 7561 grains of silver, he can defray the whole expenses of the parting or refining.

Since 26 parts of copper afford 100 of the crystallized sulphate, the tenth of copper present in the dollars, and most foreign coins, will yield nearly four times its weight of blue vitriol; a subsidiary product of considerable value to the refiner.

The works of M. Poizat are so judiciously fitted up as to be quite salubrious, and have not those "very mischievous effects upon the trachea," which Mr. Matheson states as being common in his refinery works in the Royal Mint.* But, in fact, as refining by sulphuric acid is always a nuisance to a neighbourhood, it is not suffered in the *Monnaie Royale* of Paris; but is best and most economically performed by private enterprise and fair competition, which was impossible in London, on account of the anomalous privilege, worth at least 2000*l.* a year, possessed by Mr. Matheson, who worked most extensively for private profit on a public plant, fitted up with a lofty chimney, platinum vessels to the value of 3000*l.*, and other apparatus, at the cost of the government. His charge to the crown for refining gold per lb. troy is 6*s.* 6*d.*; that of the refiners in London, who are obliged to employ the more expensive, but more condensable, nitric acid, is only 4*s.* This abuse is now reformed. That of the Parisian refiners is regulated as follows. For the dealers in the precious metals: —

For gold bullion containing silver, and more than $\frac{1}{1000}$ of gold, 6 fr. 12 c. per kilogramme, = 2 fr. 29 c. per lb. troy.

For silver bullion, containing from $\frac{1}{1000}$ to $\frac{100}{1000}$ of gold (called *dorés*), 3 fr. 27 c. per kilogramme, = 1 fr. 22 c. per lb. troy.

For the *Monnaie*, the charges are —

For gold refined by sulphuric acid, when alloyed with copper only, from $\frac{200}{1000}$ to $\frac{1}{1000}$, 5 fr. per kilogramme, = 1 fr. 86 c. per lb. troy.

For gold alloyed with copper and silver, whatever be the quantity of silver, 5 fr. 75 c. per kilogramme, = 2 fr. 12 c. per lb. troy.

* Report of Committee of House of Commons on the Mint, in 1837, p. 91.

There are about ten bullion refiners by sulphuric acid in the environs of Paris; two of whom, M. Poizat St. André, and M. Chauvière, are by far the most considerable; the former working about 300 kilogrammes (= 804 lbs. troy) daily, and the latter about two-thirds of that quantity. In former times, when competition was open in London, Messrs. Browne and Brinde were wont to treat 6 cwts. of silver, or 9 cwts. of gold alloy, daily, for several months in succession.

The result of *free trade* in refining bullion at Paris is, that the silver bars imported into London from South America, &c., are mostly sent off to Paris to be stripped of the few grains of gold which they may contain, and are then brought back to be sold here. Three grains of gold in one Paris lb. of silver, pay the refiners there for taking them out. What a disgrace is thus brought upon our manufacturing industry and skill, by the monopoly charges in refining and assaying granted to two individuals in our Royal Mint.

Mr. Bingley's charges for assaying at the Royal Mint in London, are—

For an assay of gold, 4s.; for a parting assay of gold and silver, 6s.; for a silver assay, 2s. 6d. — charges which absorb the profits of many a transaction.

The charges at the Royal Mint of Paris, for assays made under the following distinguished chemical savants—Darcey, *Directeur*; Brésant, *Verificateur*; Chevillot and Pelouse, *Essayeurs*; are—

For an assay of gold, or *doré*, (a parting assay,) 3 francs.

— silver — — — 0. 80 c. = 8d. English.

M. Gay Lussac is the assayer of the *Bureau de Garantie* at the *Monnaie Royale*, an office which corresponds to the Goldsmiths' Hall at London. The silver assays in all the official establishments of Europe, except the two in London, are made by the *humid* method, and are free from those errors and blunders which daily annoy and despoil the British bullion merchant, who is compelled by the Mint and Bank of England to buy and sell by the *capellation* assay of Mr. Bingley. See ASSAY, SILVER.

REFRIGERATION OF WORTS, &c. In August, 1826, Mr. Yandall obtained a patent for an apparatus designed for cooling worts and other hot fluids, without exposing them to evaporation. Utensils employed for this purpose, are generally called refrigerators, and are so constructed, that a quantity of cold water shall be brought in contact with the vessel which contains the heated fluid. But in every construction of refrigerator heretofore used, the quantity of cold water necessarily employed in the operation, greatly exceeded the quantity of the fluid cooled, which, in some situations, where water cannot be readily obtained, was a serious impediment and objection to the use of such apparatus.

The inventor has contrived a mode of constructing a refrigerator, so that any quantity of wort or other hot fluid may be cooled by an equal quantity of cool water; the process being performed with great expedition, simply by passing the two fluids through very narrow passages, in opposite directions, the result of which is, that the cold liquor imbibes the heat from the wort, or other fluid, and the temperature of the hot fluid is reduced in the same ratio.

Figs. 1199, 1200, 1201. represent different forms in which the apparatus is proposed to be made. The two first have zigzag passages; the third, channels running in convolute curves. These channels or passages are of very small capacity in thickness, but of great length, and of any breadth that may be required, according to the quantity of fluid intended to be cooled or heated.

Fig. 1202. is the section of a portion of the apparatus shown at *Figs. 1199, and 1200.* upon an enlarged scale; it is made by connecting three sheets of copper or any other thin metallic plates together, leaving parallel spaces between each plate for the passage of the fluids, represented by the black lines.

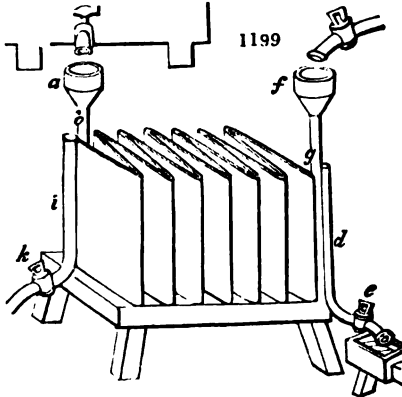
These spaces are formed by occasionally introducing between the plates thin straps, ribs, or portions of metal, by which means very thin channels are produced, and through these channels the fluids are intended to be passed, the cold liquor running in one direction, and the hot in the reverse direction.

Supposing that the passages for the fluids are each one-eighth of an inch thick, then the entire length for the run of the fluid should be about 80 feet, the breadth of the apparatus being made according to the quantity of fluid intended to be passed through it in a given time. If the channels are made a quarter of an inch thick, then their length should be extended to 160 feet; and any other dimensions in similar proportions: but a larger channel than one quarter of an inch, the patentee considers would be objectionable. It is, however, to be observed, that the length here recommended, is under the consideration, that the fluids are driven through the apparatus by some degree of hydrostatic pressure from a head in the delivery-vats above; but if the fluids flow without pressure, then the lengths of the passages need not be quite so great.

In the apparatus constructed as shown in perspective at *fig. 1199.*, and further

REFRIGERATION OF WORTS.

developed by the section, *fig. 1202.*, cold water is to be introduced at the funnel *a*,

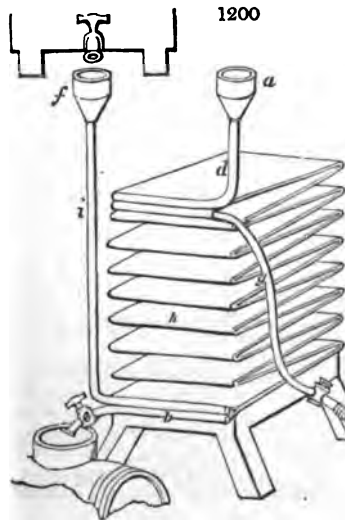


whence it passes down the pipe *b*, and through a long slit or opening in the side of the pipe, into the passage *c, c* (see *fig. 1202*), between the plates, where it flows in a horizontal direction through the channel towards the discharge-pipe *d*. When such a quantity of cold water has passed through the funnel *a*, as shall have filled the channel *c, c*, up to the level of the top of the apparatus, the cock *e* being shut, then the hot wort or liquor intended to be cooled, may be introduced at the funnel *f*, and which, descending in the pipe *g*, passes in a similar manner to the former, through a long slit or opening in the side of the pipe *g*, into the extended passage *h, h* (*fig. 1202.*), and from thence proceeds horizontally into the discharge-pipe *i*.

The two cocks *e* and *k*, being now opened, the wort or other liquor is drawn off, or otherwise conducted away through the cock *k*, and the water through *e*. If the apertures of the two cocks *e* and *k*, are equal, and the channels equal also, it follows that the same quantity of wort, &c., will flow through the channel *h, h, h*, in a given time, as of water through the channel *c, c*; and by the hot fluid passing through the apertures in contact with the side of the channel which contains the cold fluid, the heat becomes abstracted from the former, and communicated to the latter; and as the hot fluid enters the apparatus at that part which is in immediate contact with the part where the cooling fluid is discharged, and the cold fluid enters the apparatus at that part where the wort is discharged, the consequence is, that the wort or other hot liquor becomes cooled down towards its exit-pipe nearly to the temperature of cold water; and the temperature of the water, at the reverse end of the apparatus, becomes raised nearly to that of the boiling wort.

It only remains to observe, that by partially closing either of the exit-cocks, the quantity of heat abstracted from one fluid, and communicated to the other, may be regulated; for instance, if the cock *e* of the water-passage be partially closed, so as to diminish the quantity of cold water passed through the apparatus, the wort or other hot fluid conducted through the other passages will be discharged at a higher temperature, which in some cases will be desirable, when the refrigerated liquor is to be fermented.

Fig. 1200. exhibits an apparatus precisely similar to the foregoing, but different in its position; for instance, the zigzag channels are made in obliquely descending planes.

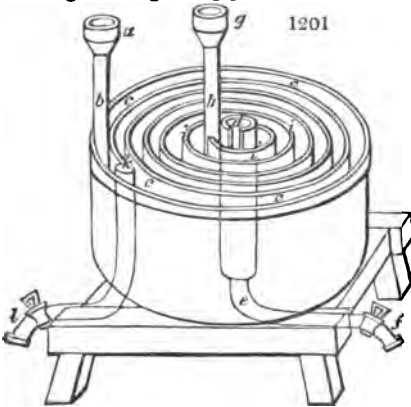


a is the funnel for the hot liquor, whence it descends through the pipe *b* into the channel *c, c* (see *fig. 1202.*), and ultimately is discharged through the pipe *b*, at the cock *e*. The cold water being introduced into the funnel *f*, and passing down the pipe *i*, enters the zigzag channel *h, h*, and, rising through the apparatus, runs off by the pipe *g*, and is discharged at the cock below.

The passages of this apparatus for heating and cooling fluids, may be bent into various contorted figures; one form found particularly convenient under some applications, is that represented at *fig. 1201.*, which is contained in a cylindrical case. The passages here run in convolute curves, the one winding in a spiral to the centre, the other receding from the centre.

The wort or other hot liquor intended to be cooled, is to be introduced at the funnel *a*, and passing down the pipe *b*, is delivered into the open passage *c*, which winds round to the central chamber *d*, and is thence discharged through the pipe *e*, at the cock *f*. The cold water enters the apparatus at the funnel *g*, and proceeding down the pipe *h*, enters the

closed channel *i*, and after traversing round through the apparatus, is in like manner discharged through the pipe *k*, at the cock *l*.



Or the hot liquor may be passed through the closed channel, and the cold through the open one; or these chambers may be both of them open at top, and the apparatus covered by a lid when at work, the principal design of which is to afford the convenience of cleaning them more readily than could be done if they were closed; or they may be both closed.

A similar ingenious apparatus for cooling brewers' worts, or wash for distillers, and also for condensing spirits in place of the ordinary worm tub, is called by the inventor, Mr. Wheeler, an Archimedes condenser, or refrigerator, the peculiar novelty of which consists in forming the chambers for the passage of the fluids in spiral channels, winding round a central tube, through which spiral channels the hot and cold fluids are to be passed in opposite directions.

Fig. 1203. represents the external appearance of the refrigerator, enclosed in a cylindrical case; *fig. 1204.*, the same, one-half of the case being removed to show the form of the apparatus within; and *fig. 1205.*, a section cut through the middle of the apparatus perpendicularly, for the purpose of displaying the internal figure of the spiral channels.

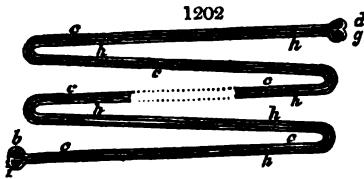
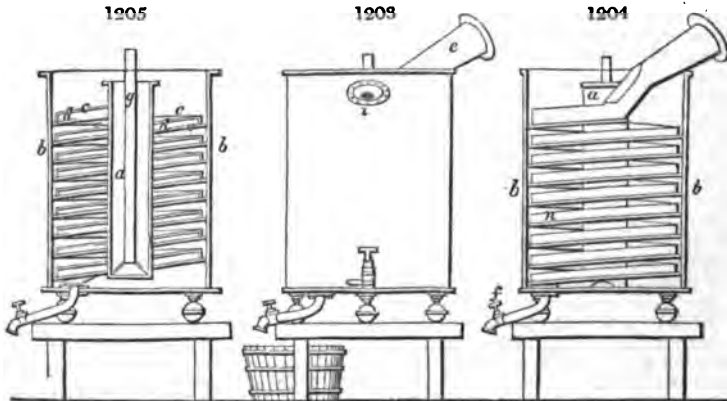
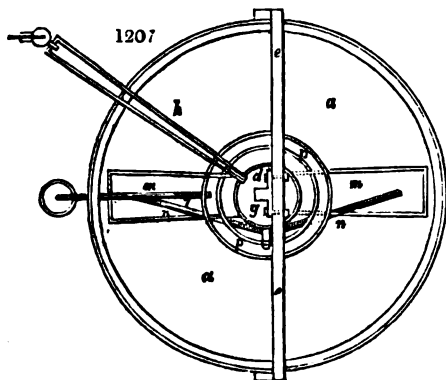
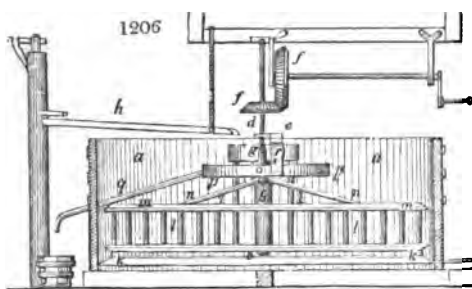


fig. 1205., a section cut through the middle of the apparatus perpendicularly, for the purpose of displaying the internal figure of the spiral channels.

The apparatus is proposed to be made of sheet copper, tinned on its surface, and is formed by cutting circular pieces of thin copper, or segments of circles, and connecting them together by rivets, solder, or by any other convenient means, as coppersmiths usually do; these circular pieces of copper being united to one another, in the way of a spiral or screw, form the chambers through which the fluids are to pass within, in an ascending or descending inclined plane.



In *figs. 1204, 1205.*, *a, a*, is the central tube or standard (of any diameter that may be found convenient), round which the spiral chambers are to be formed; *b, b*, are the sides of the outer case, to which the edges of the spiral fit closely, but need not be attached; *c, c*, are two of the circular plates of copper, connected together by rivets at the edges, in the manner shown, or by any other suitable means; *d*, is the chamber, formed by the two sheets of copper, and which is carried round from top to bottom in a spiral or circular inclined plane, by a succession of circular plates connected to each other.



mouted tube *e*, at top, and is discharged at bottom by an aperture and cock *j*. The cold water which is to be employed as the cooling material, is to be introduced through the pipe *g*, in the centre, from whence, discharging itself by a hole at bottom, the cold water occupies the interior of the cylindrical case *b*, and rises in the spiral passage *h*, between the coils of the chamber, until it ascends to the top of the vessel, and then it flows away by a spout *i*, seen in *fig.* 1203.

It will be perceived that the hot fluid enters the apparatus at top, and the cold fluid at bottom, passing each other, by means of which an interchange of temperature takes place through the plates of copper, the cooling fluid passing off at top in a heated state, by means of the calorific which it has abstracted from the hot fluid; and the hot fluid passing off through the pipe and cock at bottom, in a very reduced state of temperature, by reason of the calorific which it held having been given out to the cooling fluid.

Fig. 1206, is a side view and section of Wagenmann's apparatus for cooling wort; *fig.* 1207, a view from above. The preceding contrivances seem to be far preferable.

a, a, is the tub for receiving the apparatus, whose central upright shaft, *b*, rests upon a step *c*, in the bottom, and revolves at top in a bush at *d*, made fast to a bar *e*, fixed flat across the mouth of the tub. The shaft may be driven by the two bevel wheels *f, f*, at right angles to each other, and the horizontal rod turned by hand; or the whole may be impelled by any power. *g*, is an iron basin for receiving the cold water from the spout *h*, supplied by a well; it flows out of the basin through two tubes, *i i*, down into the lower part of the cooler *k k*. The cooler consists of two flat vessels, both of which are formed of a flat interior plate, and an arched exterior one, so that their transverse section is plano-convex. The water which flows along the tubes *i i*, spreads itself upon the bottom of the cooler, and then rises through the scabbard-shaped tubes *l l*, &c., into the upper annular vessel *m m*; whence it is urged by hydrostatic pressure, in a now heated state, through the slanting tubes *n n*, which terminate in the common pipe *o*, of the annular basin *p p*, and is thence discharged by the pipe *q*. The basin *p p*, is supported by the two bearers *r*, made fast to the cross-beam *e*. There is in the lowest part of the hollow ring at bottom, a screw plug, which may be opened when it is desired to discharge the whole contents, and to wash it with a stream of water.

REGULUS, is a term introduced by the alchemists, now nearly obsolete. It means literally a little king, and refers to the metallic state as one of royalty, compared with the native earthy condition. Antimony is the only metal now known by the name of regulus.

RENNET. The gastric juice of the stomach of the sucking calf, which, being extracted by infusion immediately after the death of the animal, serves to curdle milk. As the juice passes rapidly into putrefaction, the stomach must be salted after the outer skin has been scraped off, and all the fat and useless membranes carefully removed. It is only the inner coat which is to be preserved after it is freed from any curd or other extraneous matter in the stomach. The serum left in it should be pressed out with a cloth, and is then to be replaced in the stomach with a large quantity of the best salt. The skins, or vells as they are called, are next put into a pan and covered with a saturated solution of salt and soaked for some hours; but there should be no more brine than covers the vells. They are afterwards hung up to dry, a piece of wood being put crosswise into

each to stretch them out. They should be perfectly dried and look like parchment. In this state they may be kept in a dry place for any length of time, and are always ready for use.

Pieces of vell are cut off and soaked for some hours in wey or water, and the whole is added to the warm milk for curdling it, its strength having been first tested on a small quantity. By the rapidity with which it curdles and the form of the flakes, a judgment is formed of its strength and the quantity required for the whole milk.

RESINS (*Resines*, Fr.; *Harze*, Germ.); are proximate principles found in most vegetables, and in almost every part of them; but the only resins which merit a particular description, are those which occur naturally in such quantities as to be easily collected or extracted. They are obtained chiefly in two ways, either by spontaneous exudation from the plants, or by extraction by heat and alcohol. In the first case, the discharge of resin in the liquid state is sometimes promoted by artificial incisions made in summer through the bark into the wood of the tree.

Resins possess the following general properties: — They are soluble in alcohol, insoluble in water, and melt by the application of heat, but do not volatilize without partial decomposition. They have rarely a crystalline structure, but, like gums, they seldom affect any peculiar form. They are almost all translucent, not often colourless, but generally brown, occasionally red or green. Any remarkable taste or smell, which they sometimes possess, may be ascribed to some foreign matter, commonly an essential oil. Their specific gravity varies from 0.92 to 1.2. Their consistence is also very variable. The greater part are hard, with a vitreous fracture, and so brittle as to be readily pulverized in the cold. Some of them are soft, a circumstance probably dependent upon the presence of a heterogeneous substance. The hard resins do not conduct electricity, and they become negatively electrical by friction. When heated they melt more or less easily into a thick viscid liquid, and concrete, on cooling, into a smooth shining mass, of a vitreous fracture, which occasionally flies off into pieces, like Prince Rupert's drops; especially after being quickly cooled, and scratched with a sharp point. They take fire by contact of an ignited body, and burn with a bright flame, and the diffusion of much sooty smoke. When distilled by themselves in close vessels, they afford carbonic acid and carburetted gases, empyreumatic oil of a less disagreeable smell than that emitted by other such oils, a little acidulous water, and a very little shining charcoal. See ROSIN GAS.

Resins are insoluble in water, but dissolve in considerable quantities in alcohol, both hot and cold. This solution reddens tincture of litmus, but not syrup of violets; it is decomposed by water, and a milkiness ensues, out of which the particles of the resin gradually agglomerate. In this state it contains water, so as to be soft, and easily kneaded between the fingers; but it becomes hard and brittle again when freed by fusion from the water. The resins dissolve in ether and the volatile oils, and, with the aid of heat, combine with the unctuous oils. They may be combined by fusion with sulphur, and with a little phosphorus. Chlorine water bleaches several coloured resins, if they be diffused in a milky state through water. The carburet of sulphur dissolves them.

Resins are little acted upon by acids, except by the nitric, which converts them into artificial tan. They combine readily with the alkalis and alkaline earths, and form what were formerly reckoned soaps; but the resins are not truly saponified; they rather represent the acid constitution themselves, and, as such, saturate the salifiable bases.

Every resin is a natural mixture of several other resins, as is the case also with oils; one principle being soluble in cold alcohol, another in hot, a third in ether, a fourth in oil of turpentine, a fifth in naphtha, &c. The soft resins, which retain a certain portion of volatile oil, constitute what are called balsams. Certain other balsams contain benzoic acid. The solid resins are, *amber*, *anime*, *benzoin*, *colophony* (common resin), *copal*, *dammara*, *dragon's blood*, *elemi*, *guaiac*, *lac*, resin of *jalap*, *ladanum*, *mastic*, *sandarach*, *storax*, *takamahac*.

An ingenious memoir upon the resins of dammar, copal, and animé, has lately been published by M. Guibourt, an eminent French *pharmacie*n, from which the following extracts may be found interesting.

The *hard* copal of India and Africa, especially Madagascar, is the product of the *Hymenaea verrucosa*; it is transparent and vitreous within, whatever may be its appearance outside; nearly colourless, or of a tawny yellow; without taste or smell in the cold, and almost as hard as amber, which it much resembles, but from which it may be distinguished, 1st, by its melting and kindling at a candle-flame, and running down in drops, while amber burns and swells up without flowing; 2dly, this hard copal or animé when blown out and still hot, exhales a smell like balsam copaiva or capivi; while amber exhales an unpleasant bituminous odour; 3dly, when moistened by alcohol of 85 per cent., copal becomes sticky, and shows after drying a glazed opaque surface,

while amber is not affected by alcohol; 4thly, the copal affords no succinic acid, as amber does, on distillation.

When the pulverised copal is digested in cold alcohol of 0·830, it leaves a considerable residuum, at first pulverulent, but which swells afterwards, and forms a slightly coherent mass. When this powder is treated with boiling alcohol it assumes the consistency of a thick gluten, like crumbs of bread, but which does not stick to the fingers. Thus treated, it affords,

| | | | | |
|------------------------------------|---|---|---|-------|
| Resin soluble in cold alcohol | - | - | - | 31·42 |
| Resin dissolved in boiling alcohol | - | - | - | 4·00 |
| Resin insoluble in both | - | - | - | 65·71 |

100·83

The small excess is due to the adhesion of some of the menstruum to the resins.

Ether, boiling hot, dissolves 39·17 per cent. of copal.

Essence (spirits) of turpentine does not dissolve any of the copal, but it penetrates and combines with it at a heat of 212° Fahr.

The property of swelling, becoming viscid and elastic, which Berzelius assigns to copal, belongs not to it, but to the American resin of courbaril, or the occidental animé; and the property of dissolving entirely in ether belongs to the aromatic dammar, a friable and tender resin.

2. Resin of courbaril of Rio Janeiro, the English gum-animé, and the semi-hard copal of the French. It is characterised by forming, in alcohol, a bulky, tenacious, elastic mass. It occurs in rounded tears, has a very pale glassy aspect, transparent within, covered with a thin white powder, which becomes glutinous with alcohol. Another variety is soft, and dissolves, for the most part, in alcohol; and a third resembles the oriental copal so much as to indicate that they may both be produced from the same tree. 100 parts of the oriental and the occidental animé yield respectively the following residua:—

| | With alcohol. | With ether. | With essence. |
|------------|---------------|-------------|---------------|
| Oriental | - 65·71 | 60·83 | 111 |
| Occidental | - 43·53 | 27·50 | 75·76 |

The hard and soft copals possess the remarkable property in common of becoming soluble in alcohol, after being oxygenated in the air.

3. *Dammar puti*, or *dammar batu*.—This resin, soft at first, becomes eventually like amber, and as hard. It is little soluble in alcohol and ether, but more so in essence of turpentine.

4. *Aromatic dammar*.—This resin occurs in large orbicular masses. It is pretty soluble in alcohol. Only small samples have hitherto been obtained. Of 100 parts, 3 are insoluble in alcohol, none in ether, and 93 in essence of turpentine. M. Guibourt thinks that this resin comes from the Molucca isles. Its ready solubility in alcohol, and great hardness, render it valuable for varnish-making.

5. *Slightly aromatic dammar* leaves, after alcohol, 37 per cent.; and after ether, 17 per cent.; and after essence, 87 per cent.

6. *Tender and friable dammar selan*.—This resin occurs in considerable quantity in commerce (at Paris). It is in round or oblong tears, vitreous, nearly colourless and transparent within, dull whitish on the surfaces. It exhales an agreeable odour of olibanum, or mastic, when it is heated. It crackles with the heat of the hand, like roll-sulphur. It becomes fluid in boiling water, but brittle when cooled again. It sparkles and burns at the flame of a candle; but this being the effect of a volatile oil the combustion soon ceases.

| | | | | |
|------------------------------------|---|---|---|-------|
| Resin soluble in cold alcohol | - | - | - | 75·28 |
| Resin insoluble in boiling alcohol | - | - | - | 20·86 |

It dissolves readily and completely in cold essence of turpentine, and forms a good varnish. M. Guibourt refers the origin of this resin to the *Dammara selanica* of Rumphius. Of the preceding resins, 100 parts have left respectively

| | Alcohol of 0·830. | Insoluble in Ether. | Essence. |
|--------------------------|-------------------|------------------------|----------|
| Hard copal, or animé | - 65·71 | 60·83 | 111 |
| Tender copal | - 43·53 | 27·50 | 75·76 |
| Dammar puti | - — | — | — |
| Dammar aromatic | - 3·0 | — | 93 |
| Dammar austral | - 43·33 | 36·66 | 80 |
| Dammar slightly aromatic | - 37·00 | 17·00 | 87 |
| Dammar selan | - 20·86 | 2·00 | — |

RESIN KAURI or **COWDEE**, is a new and very peculiar substance, recently imported in considerable quantities from New Zealand, which promises to be useful in the arts. It oozes from the trunk of a noble tree called *Dammara australis*, or *Pinus kauri*, which rises sometimes to the height of 90 feet without a branch, with a diameter of 12 feet, and furnishes a log of heart timber of 11 feet. The resin, which is called Cowdee gum by the importers, is brought to us in pieces varying in size from that of a nutmeg to a block of 2 or 3 cwts. The colour varies from milk-white to amber, or even deep brown; some pieces are transparent and colourless. In hardness it is intermediate between copal and resin. The white milky pieces are somewhat fragrant, like elemi. Specific gravity, 1·04 to 1·06. It is very inflammable, burns all away with a clear bright flame, but does not drop. When cautiously fused, it concretes into a transparent hard tough mass, like shellac. It affords a fine varnish with alcohol, being harder and less coloured than mastic, while it is as soluble, and may be had probably at one-tenth of the price. A solution in alcohol, mixed with one-fourth of its bulk of a solution in oil of turpentine, forms an excellent varnish, which dries quickly, is quite colourless, clear, and hard. It is insoluble in pyro-acetic (pyroxilic?) spirit. Combined with shellac and turpentine, it forms a good sealing-wax.

REVERBERATORY FURNACE; see **COPPER**, **IRON**, and **SODA**.

RETORT. For producing coal gas, there are many modifications, varying in dimension and shape with the caprice of the constructor, and, in many cases, without any definite idea of the principle to be aimed at.

They may be divided into three general classes:

1st. The circular retort, from 12 to 20 inches in diameter, and from 6 to 9 feet in length. This retort is used in Manchester and some other places, in general for the distillation of cannel, or Scotch parrot coal. It answers for the distillation of a coal which retains its form in lumps, and is advantageous only from the facility with which its position is changed, when partially destroyed by the action of fire on the under side.

2nd. The small or London D retort, so called in consequence of its having first been used by the Chartered Company in London, being still in use at their works, and recommended by their engineer. This retort is 12 inches broad on the base, 11 inches high, and 7 feet long, carbonizing one and a half to two bushels at a charge.

3rd. The York D retort, (so called in consequence of its having been introduced by Mr. Outhit, of York,) and the modifications of it, among which I should include the elliptic retort, as having the same general purpose in view. The difference between the London and York D retorts, consists only in an extension of surface upon which the coal is spread. See **GAS-LIGHT**.

Clay retorts for gas works. Mr. Joseph Cowan, of Newcastle, has much improved the quality of clay retorts, by mixing in their composition with Newcastle fire clay, or any other good fire clay of the coal measures, sawdust, pulverized coke, or carbon obtained from the inside of gas iron retorts, &c., in such proportion as the nature of the clay may require. The more aluminous the clay, the more carbonaceous matter is needed, to take away their tendency to crack by great or unequal shrinkage. He uses a wooden cylindrical box or chamber as a mould, into which the plastic clay mixture is to be introduced through a man hole at the top. There is a core made towards one end, to the figure of the required internal form of the retort, the other part of the core being cylindrical and hollow, for the sake of lightness in the pattern. This core is placed concentrically within the cylindrical box or chamber, and is made fast thereon by a stud and key to the end plate of the cylinder. A circular plate acts as a piston within the cylinder, sliding over the core for the purpose of compressing the clay compost; which piston has several rods affixed to it, whereby mechanical force may be applied to drive the pistons forwards, in order to condense the clay into every part of the mould, which is shown by small portions of the clay oozing out of what he calls the nose piece of the mould, or end of the intended retort, which has for its transverse sectional figure that of the letter D; but to this form the patentee does not confine himself. Figures illustrative of the mould are given in *Newton's Journal*, xxvi. Plate II, fig. 1.

RHINE WINES. See **WINE**.

RHODIUM, is a metal discovered by Dr. Wollaston in 1803, in the ore of platinum. It is contained to the amount of three per cent. in the platinum ore of Antioquia in Colombia, near Barbacoas; it occurs in the Ural ore, and alloyed with gold in Mexico. The palladium having been precipitated from the muriatic solution of the platinum ore previously saturated with soda by the cyanide of mercury, muriatic acid is to be poured into the residuary liquid, and the mixture is to be evaporated to dryness, to expel the hydrocyanic acid, and convert the metallic salts into chlorides. The dry mass is to be reduced to a very fine powder, and washed with alcohol of specific gravity 0·837. This solvent takes possession of the double chlorides which the sodium forms with the plati-

num, iridium, copper, and mercury, and does not dissolve the double chloride of rhodium and sodium, but leaves it in the form of a powder of a fine dark-red colour. This salt being washed with alcohol, and then exposed to a very strong heat, affords the rhodium. But a better mode of reducing the metal upon the small scale consists in heating the double chloride gently in a glass tube, while a stream of hydrogen passes over it, and then to wash away the chloride of sodium with water.

Rhodium resembles platinum in appearance. Any heat which can be produced in a chemical furnace is incapable of fusing it; and the only way of giving it cohesive solidity, is to calcine the sulphuret or arseniuret of rhodium in an open vessel at a white heat, till all the sulphur or arsenic be expelled. A button may thus be obtained, somewhat spongy, having the colour and lustre of silver. According to Wollaston, the specific gravity of rhodium is 11. It is insoluble by itself in any acid; but when an alloy of it with certain metals, as platinum, copper, bismuth, or lead, is treated with aqua regia, the rhodium dissolves along with the other metals; but when alloyed with gold or silver, it will not dissolve along with them. It may, however, be rendered very soluble by mixing it in the state of a fine powder with chloride of potassium or sodium, and heating the mixture to a dull-red heat, in a stream of chlorine gas. It thus forms a triple salt, very soluble in water. The solutions of rhodium are of a beautiful rose colour, whence its name. In the dry way, it dissolves by heat in bisulphate of potassa; and disengages sulphurous acid gas in the act of solution. There are two oxides of rhodium. Rhodium combines with almost all the metals; and, in small quantity, melted with steel, it has been supposed to improve the hardness, closeness, and toughness of this metal. Its chief use at present is for making the inalterable nibs of the so-named rhodium pens.

RIBBON MANUFACTURE, is a modification of WEAVING, which see.

RICE, of Carolina, analyzed by Braconnot, was found to be composed of starch 85.07, of gluten 3.60, of gum 0.71, of uncrystallizable sugar 0.29, of a colourless rancid fat like suet 0.13, of vegetable fibre 4.8, of salts with potash and lime bases 0.4, and 5.0 of water.

| Year. | Imported. | Entered for Home Consumption. | Duty received. |
|-------|-----------|-------------------------------|----------------|
| | | <i>Rice.</i> | |
| | cwts. | cwts. | £ |
| 1850 | 785,451 | 435,961 | 12,789 |
| 1851 | 745,736 | 399,170 | 11,013 |
| | | <i>Rice in the husk.</i> | |
| | qrs. | qrs. | £ |
| 1850 | 37,150 | 36,430 | 1821 |
| 1851 | 31,481 | 28,291 | 1414 |

Rice Paper, as it is called, on which the Chinese and Hindoos paint flowers so prettily, is a membrane of the bread-fruit tree, the *Artocarpus incisiifolia* of naturalists.

RICE CLEANING. Various machines have been contrived for effecting this purpose, of which the following, secured by patent to Mr. Melvil Wilson, in 1826, may be regarded as a good specimen. It consists of an oblong hollow cylinder, laid in an inclined position, having a great many teeth stuck in its internal surface, and a central shaft also furnished with teeth. By the rapid revolution of the shaft, its teeth are carried across the intervals of those of the cylinder with the effect of parting the grains of rice, and detaching whatever husks or impurities may adhere to them. A hopper is set above to receive the rice, and conduct it down into the cleansing cylinder.

About 80 teeth are supposed to be set in the cylinder, projecting so as to reach very nearly the central shaft; in which there is a corresponding number of teeth, that pass freely between the former.

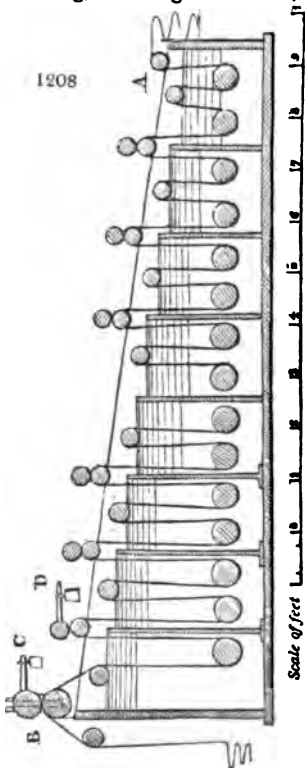
The cylinder is shown inclined in the figure which accompanies the specification; but it may be placed also upright or horizontal, and may be mounted in any convenient frame-work. The central shaft should be put in rapid rotation, while the cylinder receives a slow motion in the opposite direction. The rice, as cleaned by that action, is discharged at the lower end of the cylinder, where it falls into a shute (shoot), and is conducted to the ground. The machine may be driven by hand, or by any other convenient power.

Rice consists chiefly of starch, and therefore cannot by itself make a proper bread. It is used in the cotton factories to form weavers' dressings for warps. The Chinese reduce its flower into a pulp with hot water, and mould it into figures and plates, which they afterwards harden, and ornament with engravings, resembling those of

mother-of-pearl. When a decoction of rice is fermented and distilled, it affords the sort of ardent spirit called *arrack* in the East Indies.

RIFLE. See FIRE ARMS.

RINSING MACHINE, is one of those ingenious automatic contrivances for economizing labour, and securing uniformity of action, now so common in the factories of Lancashire. Fig. 1208. is a longitudinal middle section of an approved mechanism for rinsing pieces of calico dyed with spirit or fancy colours, and which require more delicate treatment than is compatible with hand-washing. $\Delta \times F B$ is a wooden cistern, about 21 feet long, 4 feet high at one end, 2 feet at the other, and of the ordinary width of

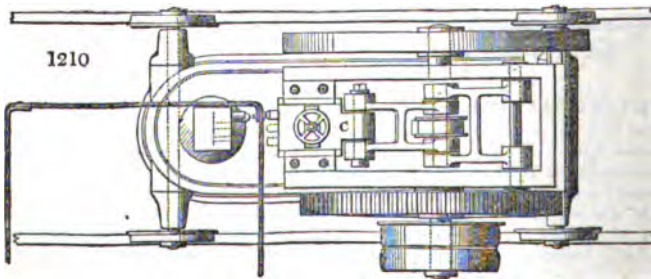
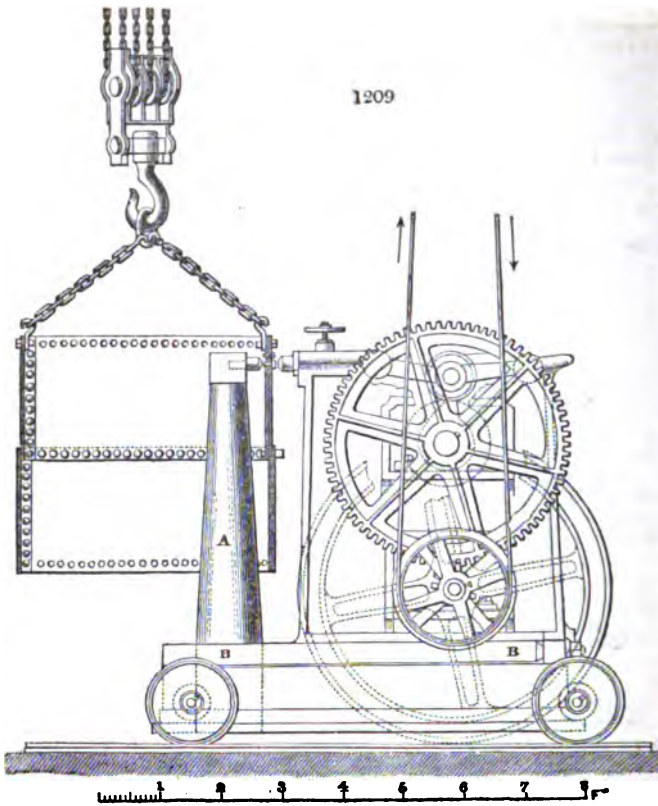


calico cloth. It is divided transversely into a series of equal compartments by partitions, decreasing in height from the upper to the lower end, the top of each of them, however, being an inch at least under the top of the enclosing side at its line of junction. Above the highest end of the trough, a pair of squeezing rollers is mounted at a ; the lower one having a pulley upon the end of its shaft, for turning it, by means of a band from one of the driving-shafts of the factory; and the upper one is pressed down upon it by weighted levers acting on the ends of its axis. The roller above the second highest partition has also a pair of squeezing rollers, with a weighted lever b . The pieces of cloth, stitched endwise, being laid upon a platform to the right hand of the cistern, are introduced over the roller a , passed down under the roller beneath it, and so up and down in a serpent-like path, from the lowest compartment of the cistern to the uppermost, being drawn through the series by the traction of the rotatory roller at a . While the long web is thus proceeding upwards from a to b , a stream of pure water is made to flow along in the opposite direction from b to a , running over the top of each partition in a thin sheet. By this contrivance, the goods which enter at a , having much loose colour upon their surface, impregnate the water strongly, but as they advance they continually get cleaner by the immersion and pressure of the successive rollers, being exposed to purer water, till at last they reach the limpid stream, and are discharged at b , perfectly bright. The rinsing operation may be modified by varying the quantity of water admitted, the speed with which the pieces are drawn through the cells, or the pressure upon the series of top rollers.

RIVETING MACHINE of Fairbairn. The invention of the riveting machine originated in a turn-out of the boiler-makers in the employ of that great engineer about fifteen years ago. On that occasion, the attempt was made to rivet two plates together by compressing the red-hot rivet in the ordinary punching-press. The success of this experiment immediately led to the construction of the original machine, in which the moveable die was forced upon the rivet by a powerful lever acted upon by a cam. A short experience proved the original machine inadequate to the numerous requirements of the boiler-maker's trade, and the present form was therefore adopted about twelve years since.

The large stem a , is made of malleable iron, and, having an iron strap $s a$, screwed round the base, it renders the whole perfectly safe in case of the dies coming in contact with a cold rivet, or any other hard substance during the process. Its construction also allows the workman to rivet angle iron along the edges, and to finish the corners of boilers, tanks, and cisterns; and the stem being now made 4 feet 6 inches high, it renders the machine more extensive in its application, and allows of its riveting the fire-box of a locomotive boiler or any other work within the given depth.

In addition to these parts, it has a broad moving slide, c , in which are three dies corresponding with others in the wrought iron stem. By using the centre die, every description of flat and circular work can be riveted, and by selecting those on the sides, it will rivet the corners, and thus complete vessels of almost every shape. This machine is in



a portable form, and can be moved off rails with care to suit the article suspended from the shears.

The introduction of the knee-joint gives to the dies a variable motion and causes the greatest force to be exerted at a proper time, viz. at the closing of the joint and finishing of the head of the rivet.

In other respects the machine operates as before, effecting by an almost instantaneous pressure what is performed in the ordinary mode by a long series of impacts. The machine fixes in the firmest manner, and completes eight rivets of $\frac{3}{4}$ inch diameter in a minute, with the attendance of two men and boys to the plates and rivets; whereas the average work that can be done by two riveters, with one "holder on" and a boy, is $40\frac{3}{4}$

inch rivets per hour; the quantity done in two cases being in the proportion of 40 to 480, or as 1 to 12, exclusive of the saving of one man's labour. The cylinder of an ordinary locomotive engine boiler 8 feet 6 inches long and 3 feet diameter can be riveted and the plates fitted completely by the machine in 4 hours; whilst to execute the same work by hand would require with an extra man twenty hours. The work produced by the machine is likewise of a superior kind to that made in the ordinary manner; the rivets being found stronger, and the boilers more free from leakage, and more perfect in every respect. The riveting is done without noise, and thus is almost entirely removed the constant deafening clamour of the boiler-maker's hammer.

ROCKETS. M. de Montgery, captain of a frigate in the French service, has written a *Traité sur les Fusées de Guerre*, in which he discusses the merits of the Congreve rockets, and describes methods of imitating them. As the subject of military projectiles is foreign to this Dictionary, I refer my readers to the above work, which is commended by the editor of the *Dictionnaire Technologique*.

ROLLING-MILL. See IRON, MINT, and PLATED MANUFACTURE.

ROOFING, ASPHALTE. Patent asphalte roofing felt, particularly applicable for warm climates. It is a non-conductor. It is portable, being packed in rolls, and not being liable to damage in carriage, it effects a saving of half the timber usually required. It can be easily applied by any unpractised person. From its lightness, weighing only about 42 lbs. to the square of 100 feet, the cost of cartage is small. The felt can be laid on from gable to gable, or across the roof from eaves to eaves. It is essential that it should be stretched tight and smooth, overlapping full one inch at the joinings, and closely nailed through the overlap, with twopenny fine clout nails, (heated in a shovel and thrown when hot into grease to prevent rust,) about $1\frac{1}{2}$ inches apart, but copper nails are preferable.

The whole roof must have a good coating of coal-tar and lime, (about two gallons of the former to six pounds of the latter), well boiled together, kept constantly stirring while boiling, and put on hot with a common tar mop, and while it is soft some coarse sharp sand may be sifted over it. The coating must be renewed every fourth or fifth year, or more or less frequently according to the climate. The gutters should be made of two folds, one over the other, cemented together with the boiling mixture.

ROPE-MAKING. The fibres of hemp which compose a rope seldom exceed in length three feet and a half, at an average. They must, therefore, be twined together so as to unite them into one; and this union is effected by the mutual circumtorsion of the two fibres. If the compression thereby produced be too great, the strength of the fibres at the points where they join will be diminished; so that it becomes a matter of great consequence to give them only such a degree of twist as is essential to their union.

The first part of the process of rope-making by hand, is that of spinning the yarns or threads, which is done in a manner analogous to that of ordinary spinning. The spinner carries a bundle of dressed hemp round his waist; the two ends of the bundle being assembled in front. Having drawn out a proper number of fibres with his hand, he twists them with his fingers, and fixing this twisted part to the hook of a whirl, which is driven by a wheel put in motion by an assistant, he walks backwards down the rope-walk, the twisted part always serving to draw out more fibres from the bundle round his waist, as in the flax-spinning wheel. The spinner takes care that these fibres are equally supplied, and that they always enter the twisted parts by their ends, and never by their middle. As soon as he has reached the termination of the walk, a second spinner takes the yarn off the whirl, and gives it to another person to put upon a reel, while he himself attaches his own hemp to the whirl hook, and proceeds down the walk. When the person at the reel begins to turn, the first spinner, who has completed his yarn, holds it firmly at the end, and advances slowly up the walk, while the reel is turning, keeping it equally tight all the way, till he reaches the reel, where he waits till the second spinner takes his yarn off the whirl hook, and joins it to the end of that of the first spinner, in order that it may follow it on the reel.

The next part of the process previous to tarring, is that of warping the yarns, or stretching them all to one length, which is about 200 fathoms in full-length rope-groudings, and also in putting a slight turn or twist into them.

The third process in rope-making is the tarring of the yarn. Sometimes the yarns are made to wind off one reel, and, having passed through a vessel of hot tar, are wound upon another, the superfluous tar being removed by causing the yarn to pass through a hole surrounded with spongy oakum; but the ordinary method is to tar it in skeins or bams, which are drawn by a capstan with a uniform motion through the tar-kettle. In this process, great care must be taken that the tar is boiling neither too fast nor too slow. Yarn for cables requires more tar than for hawser-laid ropes; and for standing and running rigging, it requires to be merely well covered. Tarred cordage has been found to be weaker than what is untarred, when it is new; but the tarred rope is not so easily injured by immersion in water.

The last part of the process of rope-making, is to lay the cordage. For this purpose two or more yarns are attached at one end to a hook. The hook is then turned the contrary way from the twist of the individual yarn, and thus forms what is called a strand. Three strands, sometimes four, besides a central one, are then stretched at length, and attached at one end to three contiguous but separate hooks, but at the other end to a single hook; and the process of combining them together, which is effected by turning the single hook in a direction contrary to that of the other three, consists in so regulating the progress of the twists of the strands round their common axis, that the three strands receive separately at their opposite ends just as much twist as is taken out of them by their twisting the contrary way, in the process of combination.

Large ropes are distinguished into two main classes, the *cable-laid* and *hawser-laid*. The former are composed of nine strands, namely, three great strands, each of these consisting of three smaller secondary strands, which are individually formed with an equal number of primitive yarns. A cable-laid rope eight inches in circumference is made up of 333 yarns or threads, equally divided among the nine secondary strands. A *hawser-laid* rope consists of only three strands, each composed of a number of primitive yarns, proportioned to the size of the rope; for example, if it be eight inches in circumference, it may have 414 yarns, equally divided among three strands. Thirty fathoms of yarn are reckoned equivalent in length to eighteen fathoms of rope cable-laid, and to twenty fathoms hawser-laid. Ropes of from one inch to two inches and a half in circumference are usually hawser-laid; of from three to ten inches, are either hawser or cable-laid; but when more than ten inches, they are always cable-laid.

Every hand-spinner in the dock-yard is required to spin, out of the best hemp, six threads, each 160 fathoms long, for a quarter of a day's work. A hawl of yarn, in the warping process, contains 336 threads.

The following are Captain Huddart's improved principles of the rope manufacture:—

1. To keep the yarns separate from each other, and to draw them from bobbins revolving upon skewers, so as to maintain the twist while the strand or primary cord is forming.
2. To pass them through a register, which divides them by circular shells of holes; the number in each concave shell being conformable to the distance from the centre of the strand, and the angle which the yarns make with a line parallel to it, and which gives them a proper position to enter.
3. To employ a tube for compressing the strand, and preserving the cylindrical figure of its surface.
4. To use a gauge for determining the angle which the yarns in the outside shell make with a line parallel to the centre of the strand, when registering; because according to the angle made by the yarns in this shell, the relative lengths of all the yarns in the strand will be determined.
5. To harden up the strand, and thereby increase the angle in the outside shell; which compensates for the stretching of the yarns, and the compression of the strands.

A great many patents have been obtained, and worked with various degrees of success, for making ropes. Messrs. Cartwright, Fothergill, Curr, Chapman, Balfour, and Huddart, have been the most conspicuous inventors in this country; but the limits of this work preclude us doing justice to their respective merits.

All improvements in the manufacture of cordage at present in use either in her Majesty's yards or in private rope-grounds, owe their superiority over the old method of making cordage to Captain Huddart's invention of the register plate and tube.

Mr. Balfour took out a patent for the manufacture of cordage about a month before Captain Huddart; but the formation of his strand was to be accomplished by what he called a top minor, (in the form of a common top, with pins to divide the yarns,) which upon trial could not make cordage so good as by the common mode. On seeing Captain Huddart's specification, Mr. Balfour, five years after, procured another patent, in which he included a plate and tube, but which was not sufficiently correct, and experience in the navy proved the insufficiency of the cordage. Captain Huddart's plate and tube were then adopted in the king's yards, and he gave his assistance for the purpose.

Captain Huddart then invented and took a patent for a machine, which by registering the strand at a short length from the tube, and winding it up as made, preserved an uniformity of twist, or angle of formation, from end to end of the rope, which cannot be accomplished by the method of forming the strands down the ground, where the twist is communicated from one end to the other of an elastic body upwards of 300 yards in length. This registering-machine was constructed with such correctness, that when some were afterwards required, no alteration could be made with advantage by the most skilful and scientific mechanic of that day, Mr. Rennie. Thus the cold register was carried to the greatest perfection.

A number of yarns cannot be put together in a cold state, without considerable vacancies, into which water may gain admission; Captain Huddart, therefore, formed

the yarns into a strand immediately as they came from the tar-kettle, which he was enabled to do by his registering-machine, and the result was most satisfactory. This combination of yarns was found by experiment to be 14 per cent. stronger than the cold register; it constituted a body of hemp and tar impervious to water, and had great advantage over any other cordage, particularly for shrouds, as after they were settled on the mast-head, and properly set up, they had scarcely any tendency to stretch, effectually secured the mast, and enabled the ship to carry the greatest press of sail.

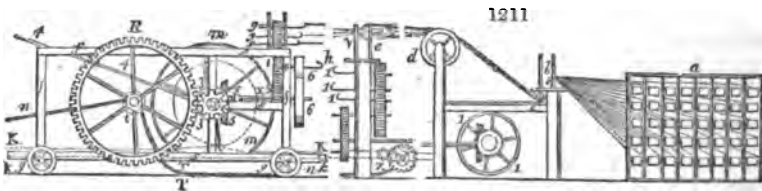
In order more effectually to obtain correctness in the formation of cables and large cordage, Captain Huddart constructed a laying machine, which has carried his inventions in rope-making to the greatest perfection, and which, founded on true mathematical principles, and the most laborious calculations, is one of the noblest monuments of mechanical ability since the improvement of the steam-engine by Mr. Watt. By this machine, the strands receive that degree of twist only which is necessary, and are laid at any angle with the greatest regularity; the pressure is regulated to give the required elasticity, and all parts of the rope are made to bear equally. In no one instance has a rope or cable thus formed been found defective in the lay, or stiff, or difficult to coil.

Such a revolution in the manufacture of cordage could not be accomplished without great expense, as the works at Limehouse fully testify; and considerable opposition necessarily arose. Captain Huddart's first invention was, however, generally adopted, as soon as the patent expired; and experience has established the great importance of his subsequent improvements.

His cordage has been supplied in large quantities to her Majesty's navy, and has received the most satisfactory reports.

The following description of one of the best modern machines for making ropes on Captain Huddart's plan, will gratify the intelligent reader.

Fig. 1211, exhibits a side elevation of the tackle-board and bobbin-frame at the head



of the ropery, and also of the carriage or rope-machine in the act of hauling out and twisting the strands.

Fig. 1212. is a front elevation of the carriage.

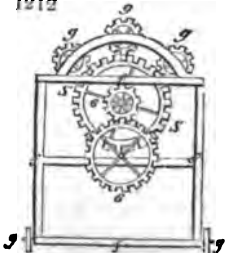
Fig. 1213. is a yarn-guide, or board, or plate, with perforated holes for the yarns to pass through before entering the nipper.

Figs. 1214. and 1215. are side and front views of the nipper for pressing the rope-yarns.

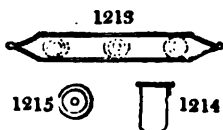
a is the frame for containing the yarn bobbins. The yarns are brought from the frame, and pass through a yarn-guide at *b*. *c* is a small roller, under which the rope-yarns pass; they are then brought over the reel *d*, and through another yarn-guide *e*, after which they enter the nippers at *v*, and are drawn out and formed into strands by the carriage. The roller and reel may be made to traverse up and down, so as to regulate the motion of the yarns.

The carriage runs on a railway. *f, f*, is the frame of the carriage; *g, g*, are the small wheels on which it is supported; *h, h*, is an endless rope, reaching from the head to the bottom of the railway, and is driven by a steam-engine;

1212



m, m, is a wheel with gubs at the back of it, over which the endless rope passes, and gives motion to the machinery of the carriage. *n*, is the ground rope for taking out the carriage, as will be afterwards described. On the shaft of *m, m*, are two bevel wheels *3, 3*, with a shifting catch between them; these bevel wheels are loose upon the shaft, but when the catch is put into either of them, this last then keeps motion with the shaft, while the other runs loose. One of these wheels serves to communicate the twist to the strand in drawing out; the other gives the opposite or after turn to the rope in closing. *4, 4*, is a lever for shifting the catch accordingly. *5*, is a third bevel wheel, which receives its



motion from either of the other two, and communicates the same to the two spur wheels 6, 6, by means of the shaft *x*. These can be shifted at pleasure; so that by applying wheels of a greater or less number of teeth above and beneath, the twist given to the strands can be increased or diminished accordingly. The upper of these two communicates motion,

by means of the shaft *o*, to another spur wheel 8, which working in the three pinions above, 9, 9, gives the twist to the strand hooks.

The carriage is drawn out in the following manner. On the end of the shaft of *m*, *m*, is the pinion 3, which, working in the large wheel *a*, gives motion to the ground-rope shaft upon its axis. In the centre of this shaft is a curved pulley or drum *t*, round which the ground rope takes one turn. This rope is fixed at the head and foot of the ropery; so that when the machinery of the carriage is set a-going by the endless rope *k*, *k*, and gives motion to the ground-rope shaft, as above described, the carriage will necessarily move along the railway; and the speed may be regulated either by the diameter of the circle formed by the gubs on the wheel *m*, *m*, or by the number of teeth in the pinion 3. At *r*, is a small roller, merely for preventing the ground rope from coming up among the machinery. At the head of the railway, and under the tackle-board, is a wheel and pinion *z*, with a crank for tightening the ground rope. The fixed machinery at the head, for hardening or tempering the strands, is similar to that on the carriage, with the exception of the ground-rope gear, which is unnecessary. The motion is communicated by another endless rope, (or short band, as it is called, to distinguish it from the other,) which passes over gubs at the back of the wheel 1, 1.

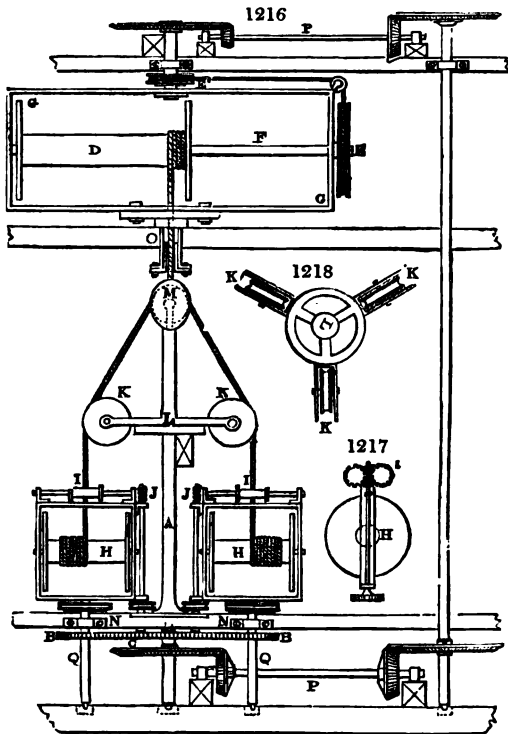
When the strands are drawn out by the carriage to the requisite length, the spur wheels 3, *z*, are put out of gear. The strands are cut at the tackle-board, and fixed to the hooks 1, 1, 1: after which they are hardened or tempered, being twisted at both ends. When this operation is finished, three strands are united on the large hook *k*, the top put in, and the rope finished in the usual way.

In preparing the hemp for spinning an ordinary thread or rope-yarn, it is only heckled over a large keg or clearer, until the fibres are straightened and separated, so as to run freely in the spinning. In this case, the hemp is not stript of the tow, or cropt, unless it is designed to spin beneath the usual grist, which is about 20 yarns for the strand of a three-inch strap-laid rope. The spinning is still performed by hand, being found not only to be more economical, but also to make a smoother thread than has yet been effected by machinery. Various ways have been tried for preparing the yarns for tarring. That which seems now to be most generally in use, is, to warp the yarns upon the stretch as they are spun. This is accomplished by having a wheel at the foot, as well as the head of the walk, so that the men are able to spin both up and down, and also to splice their threads at both ends. By this means, they are formed into a haul, resembling the warp of a common web, and a little turn is hove into the haul, to preserve it from getting foul in the tarring. The advantages of warping from the spinners, as above, instead of winding on winches, as formerly, are, 1st, the saving of this last operation altogether; 2dly, the complete check which the foreman has of the quantity of yarn spun in the day; 3dly, that the quality of the work can be subjected to the minutest inspection at any time. In tarring the yarn, it is found favourable to the fairness of the strip, to allow it to pass around or under a reel or roller in the bottom of the kettle while boiling, instead of coiling the yarn in by hand. The tar is then pressed from the yarn, by means of a sliding nipper, with a lever over the upper part, and to the end of which the necessary weight is suspended. The usual proportion of tar in ordinary ropes is something less than a fifth. In large strap-laid ropes, which are necessarily subjected to a greater press in the laying of them, the quantity of tar can scarcely exceed a sixth, without injuring the appearance of the rope when laid.

For a long period, the manner of laying the yarns into ropes was by stretching the haul on the rope-ground, parting the number of yarns required for each strand, and twisting the strands at both ends, by means of hand-hooks, or cranks. It will be obvious that this method, especially in ropes of any considerable size, is attended with serious disadvantages. The strand must always be very uneven; but the principal disadvantage, and that which gave rise to the many attempts at improvement, was, that the yarns being all of the same length before being twisted, it followed, when the rope was finished, that while those which occupied the circumference of the strand were perfectly tight, the centre yarns, on the other hand, as they were now greatly slackened by the operation of hardening or twisting the strands, actually would bear little or no part of the strain when the rope was stretched, until the former gave way. The method displayed in the preceding figures and description is among the latest and most improved. Every yarn is given out from the bobbin frame as it is required in twisting the rope; and the twist communicated in the out-going of the carriage can be increased or diminished at pleasure. In order to obtain a smooth and well-filled strand,

number of centre to that of outside yarns. In ordinary sized ropes, the strands have the fairest appearance, when the outside yarns form from $\frac{1}{3}$ ds to $\frac{1}{4}$ ths of quantity, in the portion of twist given by the carriage in drawing out and laying.

In laying cables, torsion must be given both behind and before the laying 1216, 17, 18. represent the powerful patent apparatus employed for this pur-



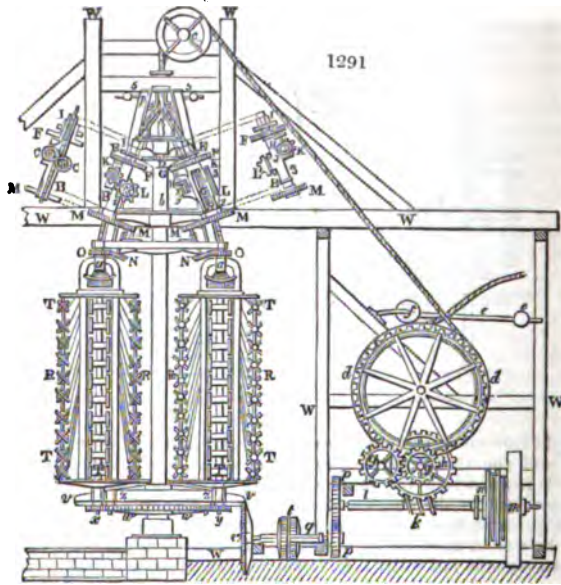
a strong upright iron pillar, supported upon the great horizontal beam *N, N*, and at its upper end the three-grooved laying top *M*. *H, H*, are two of the three bobbins or reels round which the three secondary strands or small hawsers are wound. These are drawn up by the rotation of the three feeding rollers *I, I, I*, thence over the three guide pulleys *K, K, K*, towards the laying top *M*, and finally pass over the tube *O*, to be wound upon the cable-reel *D*. The frames of the three bobbins do not revolve about the fast pillar *A*, as a common axis; but each bobbin revolves upon its own shaft *Q*, which is steadied by a bracing collet at *N*, and a conical stop at the bottom. The three bobbins are placed at an angle of 120 degrees apart, and each receives a rotatory motion upon its axis from the toothed spur wheel *B*, which is driven by the common central spur wheel *C*. Thus each of the three secondary cords receives a proper degree of twist put into it in one direction, while the cable is laid, by giving each a suitable degree of twist in an opposite direction, from the revolution of the frame *J* upon its axis, produced by the action of the endless band round the pulley *K*, *K*, *K*, and the pulley *K'* above its centre of rotation. The pulley *K* is driven by the bevel mill-gearing *F, F, F*, as also the under spur wheel *C*. *L*, in *fig. 1218*, is the ring *L*, *fig. 1216*, which bears the three guide pulleys *K, K, K*. *Fig. 1217* is a side view of the bobbin *H*, to show the worm or endless screw *S*, of *fig. 1218*, working in the two snail-toothed wheels, upon the ends of the two feed-rollers *I, I*, which serve to draw the yarns. The upright shafts of *J, J*, receive their motion from pulleys and cords near the bottom.

bottom. Instead of these pulleys, and the others x, x' , bevel-wheel gearing has been substituted with advantage, not being liable to slip, like the pulley-band mechanism. The axis of the great reel is made twice the length of the bobbin b , in order to allow of the latter moving from right to left, and back again alternately, in winding on the cable with uniformity as it is laid. The traverse mechanism of this part is, for the sake of perspicuity, suppressed in the figure.

Mr. William Norvell, of Newcastle, obtained a patent in May, 1833, for an improvement adapted to the ordinary machines employed for twisting hempen yarns into strands, affording, it is said, a simpler and more eligible mode of accomplishing that object, and also of laying the strands together, than has been hitherto effected by machinery. The yarns spun from the fibres of hemp are wound upon bobbins, and these bobbins are mounted upon axles, and hung in the frame of the machine, as shown in the elevation, *fig. 1219*, from which bobbins the several ends of yarn are passed upwards through slanting tubes; by the rotation of which tubes, and of the carriages in which the bobbins are suspended, the yarns become twisted into strands, and also the strands are laid so as to form ropes.

His improvements consist, first, in the application of three or more tubes, two of which are shown in *fig. 1219*, placed in inclined positions, so as to receive the strands immediately above the press-block a, a , and nearly in a line with Δ , the point of closing or laying the rope. n^1 , and n^2 , are opposite side views; n^3 , an edge view; and n , a side section of the same. He does not claim any exclusive right of patent for the tubes themselves, but only for their form and singular position.

Secondly, in attaching two common flat sheaves, or pulleys, c, c , *fig. 1219*, to each



of the said tubes, nearly round which each strand is lapped or coiled, to prevent it from slipping, as shown in the section n^1 . The said sheaves or pulleys are connected by a crown or centre wheel b , loose upon b, b , the main or upright axle; x, x , is a smaller wheel upon each tube, working into the said crown or centre wheel, and fixed upon the loose box 1 , on each of the tubes.

r, r , is a toothed or spur wheel, fixed also upon each of the loose boxes 1 , and working into a smaller wheel o , upon the axis 2 , of each tube; n , is a bevel wheel fixed upon the same axis with o , and working into another bevel wheel j , fixed upon the cross axle 3 of each tube; x , is a spur wheel attached to the same axis with j , at the opposite end, and working into 1 , another spur wheel of the same size upon each of the tubes. By wheels thus arranged and connected with the sheaves or pulleys, as above described, a perfectly equal strain and tension is put upon each strand as drawn forward over the pulley c .

Fig. 1220, for passing the strands proper twist into each strand and laid; this is effected by small spindles on axles 4, 4, placed parallel with each tube a.

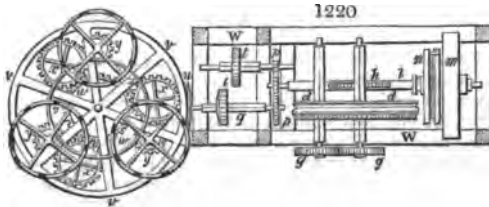
Upon the lower end of each spindle the bevel wheels x, x , are attached by other bevel wheels o, o , fixed immediately above each press-block a top end of each spindle or axle 4, 4, is attached one of the change wheels into the other change wheel fixed upon the bottom end of each c whereby the forehard or proper twist in the strands for all sizes of rope attained, by simply changing the sizes of those two last described wheels, very readily effected, from the manner in which they are attached to the tubes 4, 4.

From the angular position of the tubes towards the centre, the strand in contact at their upper ends, where the rope is laid, immediately below forehard or proper twist is given to the strands.

Fourthly, in the application of a press-block, r , of metal, in two directly above and close down to where the rope is laid at a , the inside polished, and the under end is bell-mouthed; to prevent the rope from being entering it, a sufficient grip or pressure is put upon the rope by one or two weights s, s , acting upon the press-block, so as to adjust any trifling irregular strand or in the laying; the inside of which being polished, gives smoothness to the said levers and weights, a proper tension to the rope, as it is drawn from the press-block. By the application of this block, ropes may be made at or stretched, rendering them decidedly preferable and extremely advantageous, for shipping, inclined planes, mines, &c.

The preceding description includes the whole of Mr. Norvell's improved remaining parts of the machine being similar to those now in use, may be described as follows:— A wheel or pulley c , is fixed independently of the drum which the rope passes to the drawing motion represented at the side; d, d , is wheel, round which the rope is passed, and pressed into the groove by m lever and weight e, e , acting upon the binding sheaf f , to prevent the rope from After the rope leaves the said sheaf, it is coiled away at pleasure. g, g , are 4 wheels, for varying the speed of the grooved wheel d, d , to answer the various ropes; h , is a spiral wheel, driven by the screw k , fixed upon the axle l ; m , wheel, which is driven by a belt from the shaft of the engine, or any other rotating power; n, n , is a friction strap and striking clutch. The axle q is driven change wheels p, p ; by changing the sizes of those wheels, the different speeds drum x, x , for any sizes of ropes, are at once effected.

The additional axle s , and wheels t, t , shown in *fig. 1220*, are applied occa-



reversing the motion of the said drums, and making what is usually termed ropes; *u, figs. 1219, 1220*, show a bevelled pinion, driving the main crown v which wheel carries and gives motion to the drums x, x ; w, w , is a fixed or s which gives a reverse motion to the drums, as they revolve round the same, by the intervening wheels x, x , whereby the reverse or retrograding motion is $;$ and which gives to the strands the right twist. The various retrograding r right twist for all sizes and descriptions of ropes, may be obtained by changing diameters of the pinions y, y , on the under ends of the drum spindles; the of the intervening wheels x, x , being made to slide round the ring z, z ; w , framework of the machine and drawing motion; x, x , are the bobbins containing yarns; their number is varied to correspond with the different sizes of the x

The machine here described, in elevation and plan, is calculated to make rope three to seven and one-half inches in circumference, and to an indefinite length.

Messrs. Chapman of Newcastle, to whom the art of rope-making is deeply $;$ having observed that rope yarn is considerably weakened by passing through the $;$

that tarred cordage loses its strength progressively in cold climates, and so rapidly in hot climates as to be scarcely fit for use in three years, discovered that the deterioration was due to the reaction of the mucilage and acid of the tar. They accordingly proposed the following means of amelioration. 1. Boiling it with water, in order to remove these two soluble constituents. 2. Concentrating the washed tar by heat, till it becomes pitchy, and then restoring the plasticity which it thereby loses, by the addition of tallow, or animal or expressed oils.

In 1807, the same able engineers obtained a patent for a method of making a belt or flat band, of two, three, or more strands of shroud or hawser-laid rope, placed side by side, so as to form a band of any desired breadth, which may be used for hoisting the kibbles and corves in mine-shafts, without any risk of its losing twist by rotation. The ropes should be laid with the twist of the one strand directed to the right hand, that of the other to the left, and that of the yarns the opposite way to the strands, whereby perfect flatness is secured to the band. This parallel assemblage of strands has been found also to be stronger than when they are all twisted into one cylinder. The patentees at the same time contrived a mechanism for piercing the strands transversely, in order to brace them firmly together with twine. Flat ropes are usually formed of hawsers with three strands, softly laid, each containing 33 yarns, which with four ropes compose a cordage four and a half inches broad, and an inch and a quarter thick, being the ordinary dimensions of the grooves in the whim-pulleys round which they pass.

RELATIVE STRENGTH OF CORDAGE, shroud laid.

| Size. | Warm Register. | | | | Cold Register. | | | | Common Staple. | | | |
|-------------------|----------------|------|------|------|----------------|------|------|------|----------------|------|------|------|
| | Tons. | Cwt. | Qrs. | Lbs. | Tons. | Cwt. | Qrs. | Lbs. | Tons. | Cwt. | Qrs. | Lbs. |
| 3 inches bore - - | 3 | 17 | — | 16 | 3 | 5 | 3 | 16 | 2 | 9 | 1 | 24 |
| 3½ — | 5 | 5 | — | — | 4 | 9 | 2 | 21 | 3 | 6 | 1 | 27 |
| 4 — | 6 | 17 | — | 16 | 5 | 17 | — | 4 | 4 | 5 | 3 | 7 |
| 4½ — | 8 | 13 | 2 | 8 | 7 | 5 | 3 | 1 | 5 | 1 | 2 | 6 |
| 5 — | 10 | 14 | 1 | 4 | 9 | 3 | — | 4 | 6 | 9 | 2 | 8 |
| 5½ — | 12 | 19 | 2 | 4 | 11 | 1 | 1 | 25 | 7 | 12 | — | 22 |
| 6 — | 14 | 15 | 2 | 24 | 13 | 3 | 2 | 8 | 8 | 17 | 1 | 20 |
| 6½ — | 18 | 2 | — | 10 | 15 | 9 | 1 | 9 | 9 | 16 | 3 | 14 |
| 7 — | 21 | — | — | — | 17 | 18 | 3 | 8 | 11 | 4 | 1 | 21 |
| 7½ — | 24 | 2 | — | 16 | 20 | 11 | 3 | 9 | 12 | 8 | 3 | 6 |
| 8 — | 27 | 8 | 1 | 26 | 23 | 8 | 2 | 8 | 13 | 2 | 3 | 12 |

The above statement is the result of several hundred experiments.

ROPE, Exhibition.—Specimens of Smith's patent galvanized and ungalvanized iron and copper wire ropes used for railway inclines, various mining operations, including pit guides, suspension bridges, standing rigging, lightning conductors, window and conservatory sashes, fencing, and submarine telegraphs.

Iron wire ropes are of equal strength with a hempen rope of four times the weight, and resist the wear and tear they are subjected to in "running gear" twice as long. If the surface of a wire rope be left in any part unprotected by some coating impervious to moisture, the internal fibres become in process of time oxidized, and unseen decay goes forward. Iron cleaned by acid, and plunged into a bath containing melted zinc, becomes coated with that metal, and the parts left unsized alone rust. Iron thus treated is said to be galvanized.

Specimens of submarine telegraph wire rope. Round wire rope prepared for use. The improvement is stated to consist in preventing the wires and strands from being twisted on themselves in the process of laying them round centre cores of hemp, in giving an equal tension to each individual wire, and in preserving the interior surface from corrosion by saturating the cores of hemp with tar, &c.

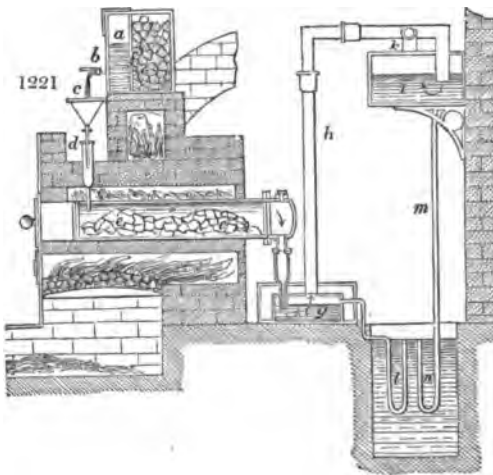
Sample of wire strand, used for fencing, signal cord, &c. Sample of wire ropes. Wire rope for suspension bridges, and cable laid wire ropes. Wire ropes showing the mode of splicing. Patent wire ropes for submarine telegraph; lightning conductor; copper window-sash cord and picture cord. Patent flat wire rope, and guide rope for coal pits, &c. Rope which has been at work constantly for five years.

ROSIN, or COLOPHANY (*Galipot*, Fr.; *Fichtenharz*, Germ.); is the rosin left after distilling off the volatile oil from the different species of turpentine. Yellow rosin contains some water, which black rosin does not. See **TURPENTINE**.

ROSIN GAS. *Fig. 1221* exhibits the retort and its appendages, as erected by Messrs. Taylor and Martineau, under the direction of the patentee, Professor Daniel, F. R. S.

I have introduced this manufacturing project, not as a pattern to imitate, but as an example to deter; as affording a very instructive lesson of the danger of rushing headlong into most extensive enterprises, without fully verifying, upon a moderate scale, the probability of their ultimate success. The capital, labour, and time annually wasted upon visionary schemes of this sort, got up by chamber chemists, are incalculably great. No more essential service could be rendered to the cause of productive industry, than to unmask the thousand and one chimerical inventions which disgrace our lists of patents during the last thirty years. These remarks have been suggested by the circumstance, that 50,000*l.* were squandered upon the rosin-gas concern; a fact communicated to me by an eminent capitalist, who was induced by fallacious statements to embark largely in the speculation. Had 100*l.* been employed beforehand, by a dispassionate practical man, in making judicious trials, and in calculating the chances of eventual profit and loss, it would have been demonstrated, as clearly as noon-day, that rosin could never compete with pitcoal in the production of gas-light. Whatever ingenuity was expended in getting up the following apparatus, may be regarded as an additional *ignis fatuus* to mislead the public, and divert their thoughts from the abyss that lay before them. The main preliminary to be settled, in all new undertakings, is the soundness of the principle. By neglecting this point, projectors perpetually realize the expiatory fable of the Danaïds.

The retort *e, e, fig. 1221.*, is seen charged with coke, which is in the first instance raised



to a bright red heat, by means of the furnace beneath. The common brown rosin of commerce, which is deposited in the tank *a*, is to be mixed with the essential oil (condensed from the rosin vapours in a preceding operation) in the proportion of one hundred pounds of the former to ten gallons of the latter. The influence of the flame and heated air beneath serves to preserve this in a fluid state, and by a damper passing across the aperture in the chimney, the temperature of the fluid may be exactly regulated. A wire-gauze screen at *f*, reaches to the bottom of the tank, and prevents the solid rosin, or any impurity with which it may be mixed, from choking the stopcock.

The melted rosin having passed by the stopcock *b*, funnel *c*, and syphon *d*, into the retort, falls on the coke, and in its passage through the ignited mass, becomes decomposed. On arriving at the other end of the retort, a large portion of the oil of turpentine, in the form of condensable vapour, is separated by the refrigerator *g*; this is supplied with water from a cistern above and the non-condensable vapour or gas passes up the tube *h*, and dips beneath the surface of the fluid in the vessel *i*. This completes the condensation; and the gas proceeds in a perfectly pure state, by the pipe *k*, to the gasometer, or rather to the floating reservoir, for use.

The essential oil, when it leaves the refrigerator, is conveyed, by the syphon *l*, to a cistern beneath. The necessity for employing a syphon will be apparent, when it is

borne in mind that the tube prevents the escape of the gas, which would otherwise pass away from the box with the essential oil. Another pipe and syphon m, n, serve to convey the condensed essential oil from the top cistern.

ROTTEN-STONE. See TRIPOLI.

ROUGE. (*Fard, Fr.*) The only cosmetic which can be applied without injury to brighten a lady's complexion, is that prepared, by the following process, from safflower (*Carthamus tinctorius*). The flowers, after being washed with pure water till it comes off colourless, are dried, pulverized, and digested with a weak solution of crystals of soda, which assumes thereby a yellow colour. Into this liquor a quantity of finely carded white cotton wool is plunged, and then so much lemon juice or pure vinegar is added as to supersaturate the soda. The colouring matter is disengaged, and falls down in an impalpable powder upon the cotton filaments. The cotton, after being washed in cold water, to remove some yellow colouring particles, is to be treated with a fresh solution of carbonate of soda, which takes up the red colouring matter in a state of purity. Before precipitating this pigment a second time by the acid of lemons, some soft powdered tale should be laid in the bottom of the vessel, for the purpose of absorbing the fine rouge, in proportion as it is separated from the carbonate of soda, which now holds it dissolved. The coloured mixture must be finally triturated with a few drops of olive oil, in order to make it smooth and marrowy. Upon the fineness of the tale, and the proportion of the safflower precipitate which it contains, depend the beauty and value of the cosmetic. The rouge of the above second precipitation is received sometimes upon bits of fine-twisted woollen stuff, called *cropons*, which ladies rub upon their cheeks.

RUBY. See LAFIDARY.

RUM, is a variety of ardent spirits, distilled in the West Indies, from the fermented skimmings of the sugar teaches, mixed with molasses, and diluted with water to the proper degree. A sugar plantation in Jamaica or Antigua, which makes 200 hogsheads of sugar, of about 16 cwt. each, requires, for the manufacture of its rum two copper stills; one of 1000 gallons for the wash, and one of 600 gallons for the low wines, with corresponding worm refrigeratories. It also requires two cisterns, one of 3000 gallons for the lees or spent wash of former distillations, called *dunder* (*Quasi redundar, Span.*), another for the skimmings of the clarifiers and teaches of the sugar-house; along with twelve, or more, fermenting cisterns or tuns.

Lees that have been used more than three or four times are not considered to be equally fit for exciting fermentation, when mixed with the sweets, as fresher lees. The wort is made, in Jamaica, by adding to 1000 gallons of *dunder*, 120 gallons of molasses, 720 gallons of skimmings (= 120 of molasses in sweetness), and 160 gallons of water; so that there may be in the liquid nearly 12 per cent. of solid saccharum. Another proportion, often used, is 100 gallons of molasses, 200 gallons of lees, 300 gallons of skimmings, and 400 of water; the mixture containing, therefore, 15 per cent. of sweets. These two formulæ prescribe so much spent wash, according to my opinion, as would be apt to communicate an unpleasant flavour to the spirits. Both the fermenting and flavouring principles reside chiefly in the fresh cane juice, and in the skimmings of the clarifier; because, after the syrup has been boiled, they are in a great measure dissipated. I have made many experiments upon fermentation and distillation from West India molasses, and always found the spirits to be perfectly exempt from any rum flavour.

The fermentation goes on most uniformly and kindly in very large masses, and requires from 9 to 15 days to complete; the difference of time depending upon the strength of the wort, the condition of its fermentable stuff, and the state of the weather. The progress of the attenuation of the wash should be examined from day to day with a hydrometer, as I have described in the article **DISTILLATION**. When it has reached nearly to its *maximum*, the wash should be as soon as possible transferred by pumps into the still, and worked off by a properly regulated heat; for if allowed to stand over, it will deteriorate by acetification. Dr. Higgin's plan, of suspending a basket full of limestone in the wash-tuns, to counteract the acidity, has not, I believe, been found to be of much use. It would be better to cover up the wash from the contact of atmospheric air, and to add perhaps a very little *sulphite* of lime to it, both of which means would tend to arrest the acetous fermentation. But one of the best precautions against the wash becoming sour, is to preserve the utmost cleanliness among all the vessels in the distillery. They should be scalded at the end of every round with boiling water and quicklime.

About 115 gallons of proof rum are usually obtained from 1200 gallons of wash. The proportion which the product of rum bears to that of sugar, in very rich moist plantations, is rated, by Edwards, at 82 gallons of the former to 16 cwt. of the latter; but the more usual ratio is 200 gallons of rum to 3 hogsheads of sugar. But this proportion will necessarily vary with the value of rum and molasses in the market, since whichever fetches the most remunerating price, will be brought forward in the greatest quantity. In one considerable estate in the island of Grenada, 92 gallons of rum were made for every hogshead (16 cwt.) of sugar. See **STILL**.

| | Imported. | Retained for Consumption. | | Duty received. |
|------|-----------|---------------------------|------------|----------------|
| | Gallons. | Gallons. | £. | £. |
| 1850 | 4,194,683 | 2,902,212 | 1,100,286. | |
| 1851 | 4,747,081 | 2,880,775 | 1,098,200. | |

RUSSIAN LEATHER, as tanned at Kazan. The hides to be tanned may be either fresh from the animal or dry, no matter which; they are first laid to soak for 3 days and nights in a solution of potash, to which some quicklime is added. The potash used is made of the tree called in Russ ilim (the common elm), which sort is said to be preferable to any other, if not essential; it is not purified, so that it is of a brown colour and of an earthy appearance: about 12 poods of this, (the pood is 36 lbs. English) and 2 poods of lime, serve for 100 skins. As they have no way of ascertaining the degree of causticity of the alkali but by its effect upon the tongue, when they find it weak they let the skins lie longer in the solution.

When the skins are taken out of this solution they are carried to the river, and left under water for a day and a night.

Next a vedro of dog's dung is boiled in as much water as is enough to soak 50 skins, (the vedro is equal to 2.696 English imperial gallons), but in the winter time, when the dung is frozen, twice that quantity is found necessary. The skins are put into this solution, not while it is boiling hot, but when at the heat which the hand can bear; in this they lie one day and one night.

The skins are then sewed up so as to leave no hole; in short, so as to be water-tight; about one third of what the skin will contain is then filled up with the leaves and small twigs chopped together of the plant called in Russ Toloknanka (*Arbutus uva-ursi*, sometimes called bear berry), which is brought from the environs of Solikamskaga, and the skin is then filled up with water.

The skins thus filled are laid one on the other in a large trough, and heavy stones upon them, so as by their weight to press the infusion through the pores of the skin in about 4 hours; yet, as it was said at the same time, that the skins are filled up with the same water which had been pressed out 10 times successively, and that the whole operation takes but one day and one night, this leaves but $2\frac{1}{2}$ hours for each time.

The skins are then taken to the river and washed, and are ready for the dyeing. The whitest skins are laid aside for the red and yellow leather.

(The operations in dyeing follow, but are here omitted.)

To soften the skins after dyeing, they are harassed by a knife, the point of which is curved upwards.

RUST, is the orange-yellow coat of peroxide which forms upon the surface of iron exposed to moist air. Oil-paint, varnish, plumbago, or a film of caoutchouc, may be employed, according to circumstances, to prevent the rusting of iron utensils.

RYE, consists, according to the analysis of Einhof, of 24.2 of husk, 65.6 of flour, and 10.2 of water, in 100 parts. This chemist found in 100 parts of the flour, 61.07 of starch, 9.48 of gluten, 3.28 of vegetable albumen, 3.28 of uncrystallizable sugar, 11.09 of gum, 6.38 of vegetable fibre, and the loss was 5.62, including a vegetable acid not yet investigated. Some phosphate of lime and magnesia are also present. See GIN.

S.

SABOTIERE. The apparatus for making ices, called "sabotière," is composed of two principal parts—a pail which is indented towards the top and covered; and the sabotière, or inner vessel, slightly conical, which is inserted in a pail, on which it rests by a projecting border or rim; this vessel is closed at the bottom like a cup, and open at the top to admit the creams to be iced. It is closed at the top by a cover furnished with a handle and a hook, which fastens it to the rim of the vessel. This apparatus works as follows:—The freezing mixture, composed of sulphate of soda pulverized and hydrochloric acid, is turned into the pail, and the creams to be iced into the inner vessel; its cover is then fastened by the hook, and the vessel is set into the pail among the freezing liquid; then taking the whole by the handle of the sabotière, an alternate motion of rotation is given to it for about a quarter of an hour, when the cream is sufficiently frozen. The cover is opened from time to time, and the mixture well stirred with a spoon adapted for the purpose. The freezing mixture must be removed every 15 or 20 minutes. There is a measure for the freezing mixture, which contains 2 parts of salt and 1 of acid. The pail is furnished with a handle, and is surrounded with thick woollen cloth to exclude the effect of outward air.

SACCHAROMETER is the name of a hydrometer, adapted by its scale to point out the proportion of sugar, or the saccharine matter of malt, contained in a solution of any specific gravity. Brewers, distillers, and the Excise, sometimes denote by the term gravity, the excess of weight of 1000 parts of a liquid by volume above the weight of a like volume of distilled water, so that if the specific gravity be 1045, 1070, 1090, &c., the gravity is said to be 45, 70, or 90; at others, they thereby denote the weight of saccharine matter in a barrel (36 gallons) of worts; and again, they denote the excess in weight of a barrel of worts over a barrel of water, equal to 36 gallons, or 360 pounds. This and the first statement are identical, only 1000 is the standard in the first case, and 360 in the second.

The saccharometer now used by the Excise, and by the trade, is that constructed by the late Mr. R. B. Bate, well known for the accuracy of his philosophical and mathematical instruments. The tables published by him for ascertaining the value of wort or wash, and low wines, are preceded by explicit directions for their use. "The instrument is composed of brass; the ball or float being a circular spindle, in the opposite ends of which are fixed a stem and a loop. The stem bears a scale of divisions numbered downwards from the first to 30; these divisions, which are laid down in an original manner, observing a diminishing progression according to true principles; therefore each division correctly indicates the one thousandth part of the specific gravity of water; and further, by the alteration made in the bulk of the saccharometer at every change of poise, each of the same divisions continues to indicate correctly the said one thousandth part throughout."

In my own practice, I prefer to take specific gravities of all liquids whatever with a glass globe containing 500 or 1000 grains of distilled water at 60° Fahr., when it is closed with a capillary-bored glass stopper; and with the gravity so taken, I look into a table constructed to show the quantity per cent. of sugar, malt-extract, or of any other solid, proportional to the density of the solution. By bringing the liquid in the gravity bottle to the standard temperature, no correction on this account is needed. Mr. Bate's elaborate table contains all these equations correctly for solutions of sugar of every successive specific gravity. When employed in such researches by the Molasses Committee of the House of Commons in the year 1830, I found that the specific gravities of solutions of the concrete extract of malt differed somewhat from those of solutions of sugar, as given by Mr. Bate. See *BREA*.

The following Table shows the Quantities of Sugar contained in Syrups of the annexed Specific Gravities. It was the result of experiments carefully made.

| Experimental Spec. Gravity of Solution at 60° F. | Sugar in 100 by Weight. | Experimental Spec. Gravity of Solution at 60° F. | Sugar in 100 by Weight. |
|--|-------------------------|--|-------------------------|
| 1·3260 | 66·666 | 1·1045 | 25·000 |
| 1·2310 | 50·000 | 1·0905 | 21·740 |
| 1·1777 | 40·000 | 1·0820 | 20·000 |
| 1·4400 | 33·333 | 1·0635 | 16·666 |
| 1·1340 | 31·250 | 1·0500 | 12·500 |
| 1·1250 | 29·412 | 1·0395 | 10·000 |
| 1·1110 | 26·316 | | |

N. B. The column in the opposite table, marked *Solid extract by weight*, is Mr. Bate's; it may be compared with this short table, and also with the table of malt infusions in the Dictionary.

If the decimal part of the number denoting the specific gravity of syrup be multiplied by 26, the product will denote very nearly the quantity of sugar per gallon in pounds at the given specific gravity.*

SADDLER'S IRONMONGERY. *Lowe, John and Henry, Clarence Works, Birmingham,—Manufacturers.* The manufacture of saddlers' ironmongery is principally located at Birmingham and in the neighbouring towns of Wolverhampton, Walsall, &c. Its object is the production of bits, spurs, stirrups, curb-chains, &c. These are formed out of iron and steel by the ordinary process of hammering; and are finished by japanning, tinning, burnishing, or plating with brass or silver. Some produced for the South American market are of very fantastic shapes, and richly gilt; they differ from those

* This rule was annexed to an extensive table, representing the quantities of sugar per gallon, corresponding to the specific gravities of the syrups, constructed by the Author, for the Excise, in subsergency to the Beet-root bill.

SACCHAROMETER.

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Table exhibiting the Quantity of Sugar, in Pounds Avoirdupois which is contained in One Gallon of Syrup, at successive Degrees of Density, at 60° F.

| Specific Gravity. | Lbs. per Gallon. | Extract by Weight in 100. | Specific Gravity. | Lbs. per Gallon. | Extract by Weight in 100. | Specific Gravity. | Lbs. per Gallon. | Specific Gravity. | Lbs. per Gallon. |
|-------------------|------------------|---------------------------|-------------------|------------------|---------------------------|-------------------|------------------|-------------------|------------------|
| 1.000 | 0.0000 | .0000 | 1.077 | 2.0197 | 1.851 | 1.154 | 4.0980 | 1.221 | 6.1474 |
| 1.001 | 0.0255 | .0025 | 1.078 | 2.0455 | 1.773 | 1.155 | 4.1148 | 1.222 | 6.1743 |
| 1.002 | 0.0510 | .0051 | 1.079 | 2.0713 | 1.695 | 1.156 | 4.1319 | 1.223 | 6.2012 |
| 1.003 | 0.0765 | .0077 | 1.080 | 2.1006 | 1.618 | 1.157 | 4.1588 | 1.224 | 6.2281 |
| 1.004 | 0.1020 | .0102 | 1.081 | 2.1275 | 1.541 | 1.158 | 4.1857 | 1.225 | 6.2551 |
| 1.005 | 0.1275 | .0128 | 1.082 | 2.1543 | 1.463 | 1.159 | 4.2128 | 1.226 | 6.2822 |
| 1.006 | 0.1530 | .0153 | 1.083 | 2.1811 | 1.385 | 1.160 | 4.2502 | 1.227 | 6.3093 |
| 1.007 | 0.1785 | .0179 | 1.084 | 2.2080 | 1.307 | 1.161 | 4.2771 | 1.228 | 6.3363 |
| 1.008 | 0.2040 | .0204 | 1.085 | 2.2359 | 1.229 | 1.162 | 4.3040 | 1.229 | 6.3631 |
| 1.009 | 0.2295 | .0230 | 1.086 | 2.2627 | 1.151 | 1.163 | 4.3309 | 1.230 | 6.3903 |
| 1.010 | 0.2550 | .0255 | 1.087 | 2.2894 | 1.073 | 1.164 | 4.3578 | 1.231 | 6.4159 |
| 1.011 | 0.2805 | .0280 | 1.088 | 2.3161 | 1.000 | 1.165 | 4.3847 | 1.232 | 6.4401 |
| 1.012 | 0.3060 | .0306 | 1.089 | 2.3438 | 0.921 | 1.166 | 4.4115 | 1.233 | 6.4650 |
| 1.013 | 0.3315 | .0331 | 1.090 | 2.3710 | 0.843 | 1.167 | 4.4383 | 1.234 | 6.4902 |
| 1.014 | 0.3570 | .0356 | 1.091 | 2.3987 | 0.765 | 1.168 | 4.4652 | 1.235 | 6.5153 |
| 1.015 | 0.3825 | .0381 | 1.092 | 2.4265 | 0.687 | 1.169 | 4.4923 | 1.236 | 6.5402 |
| 1.016 | 0.4080 | .0406 | 1.093 | 2.4542 | 0.609 | 1.170 | 4.5201 | 1.237 | 6.5651 |
| 1.017 | 0.4335 | .0431 | 1.094 | 2.4799 | 0.531 | 1.171 | 4.5468 | 1.238 | 6.5902 |
| 1.018 | 0.4590 | .0456 | 1.095 | 2.5061 | 0.453 | 1.172 | 4.5722 | 1.239 | 6.6152 |
| 1.019 | 0.4845 | .0481 | 1.096 | 2.5329 | 0.375 | 1.173 | 4.5983 | 1.240 | 6.6402 |
| 1.020 | 0.5100 | .0506 | 1.097 | 2.5598 | 0.297 | 1.174 | 4.6242 | 1.241 | 6.6681 |
| 1.021 | 0.5355 | .0531 | 1.098 | 2.5866 | 0.219 | 1.175 | 4.6505 | 1.242 | 6.6960 |
| 1.022 | 0.5609 | .0555 | 1.099 | 2.6130 | 0.141 | 1.176 | 4.6764 | 1.243 | 6.7240 |
| 1.023 | 0.5863 | .0580 | 1.100 | 2.6404 | 0.063 | 1.177 | 4.7023 | 1.244 | 6.7521 |
| 1.024 | 0.6117 | .0605 | 1.101 | 2.6663 | 0.000 | 1.178 | 4.7281 | 1.245 | 6.7800 |
| 1.025 | 0.6371 | .0629 | 1.102 | 2.6921 | 0.000 | 1.179 | 4.7539 | 1.246 | 6.8081 |
| 1.026 | 0.6625 | .0654 | 1.103 | 2.7188 | 0.000 | 1.180 | 4.7802 | 1.247 | 6.8362 |
| 1.027 | 0.6879 | .0678 | 1.104 | 2.7446 | 0.000 | 1.181 | 4.8051 | 1.248 | 6.8643 |
| 1.028 | 0.7133 | .0703 | 1.105 | 2.7704 | 0.000 | 1.182 | 4.8303 | 1.249 | 6.8921 |
| 1.029 | 0.7387 | .0727 | 1.106 | 2.7951 | 0.000 | 1.183 | 4.8554 | 1.250 | 6.9201 |
| 1.030 | 0.7640 | .0752 | 1.107 | 2.8227 | 0.000 | 1.184 | 4.8802 | 1.251 | 6.9481 |
| 1.031 | 0.7893 | .0776 | 1.108 | 2.8485 | 0.000 | 1.185 | 4.9051 | 1.252 | 6.9762 |
| 1.032 | 0.8146 | .0800 | 1.109 | 2.8740 | 0.000 | 1.186 | 4.9300 | 1.253 | 7.0033 |
| 1.033 | 0.8399 | .0825 | 1.110 | 2.9001 | 0.000 | 1.187 | 4.9552 | 1.254 | 7.0314 |
| 1.034 | 0.8652 | .0849 | 1.111 | 2.9263 | 0.000 | 1.188 | 4.9803 | 1.255 | 7.0595 |
| 1.035 | 0.8905 | .0873 | 1.112 | 2.9522 | 0.000 | 1.189 | 5.0054 | 1.256 | 7.0876 |
| 1.036 | 0.9149 | .0897 | 1.113 | 2.9780 | 0.000 | 1.190 | 5.0304 | 1.257 | 7.1157 |
| 1.037 | 0.9449 | .0921 | 1.114 | 3.0045 | 0.000 | 1.191 | 5.0563 | 1.258 | 7.1438 |
| 1.038 | 0.9748 | .0945 | 1.115 | 3.0304 | 0.000 | 1.192 | 5.0822 | 1.259 | 7.1719 |
| 1.039 | 1.0099 | .0969 | 1.116 | 3.0563 | 0.000 | 1.193 | 5.1080 | 1.270 | 7.2000 |
| 1.040 | 1.0400 | .0993 | 1.117 | 3.0821 | 0.000 | 1.194 | 5.1341 | 1.271 | 7.2601 |
| 1.041 | 1.0653 | .1017 | 1.118 | 3.1080 | 0.000 | 1.195 | 5.1602 | 1.272 | 7.2902 |
| 1.042 | 1.0905 | .1041 | 1.119 | 3.1343 | 0.000 | 1.196 | 5.1863 | 1.273 | 7.3203 |
| 1.043 | 1.1159 | .1065 | 1.120 | 3.1610 | 0.000 | 1.197 | 5.2124 | 1.274 | 7.3504 |
| 1.044 | 1.1413 | .1089 | 1.121 | 3.1871 | 0.000 | 1.198 | 5.2381 | 1.275 | 7.3805 |
| 1.045 | 1.1665 | .1113 | 1.122 | 3.2130 | 0.000 | 1.199 | 5.2639 | 1.276 | 7.4106 |
| 1.046 | 1.1918 | .1136 | 1.123 | 3.2389 | 0.000 | 1.200 | 5.2901 | 1.277 | 7.4407 |
| 1.047 | 1.2171 | .1160 | 1.124 | 3.2658 | 0.000 | 1.201 | 5.3160 | 1.278 | 7.4708 |
| 1.048 | 1.2424 | .1184 | 1.125 | 3.2916 | 0.000 | 1.202 | 5.3422 | 1.279 | 7.5009 |
| 1.049 | 1.2687 | .1207 | 1.126 | 3.3174 | 0.000 | 1.203 | 5.3681 | 1.280 | 7.5310 |
| 1.050 | 1.2940 | .1231 | 1.127 | 3.3431 | 0.000 | 1.204 | 5.3941 | 1.281 | 7.5611 |
| 1.051 | 1.3205 | .1254 | 1.128 | 3.3690 | 0.000 | 1.205 | 5.4203 | 1.282 | 7.5912 |
| 1.052 | 1.3473 | .1278 | 1.129 | 3.3949 | 0.000 | 1.206 | 5.4462 | 1.283 | 7.6213 |
| 1.053 | 1.3739 | .1301 | 1.130 | 3.4211 | 0.000 | 1.207 | 5.4720 | 1.284 | 7.6514 |
| 1.054 | 1.4004 | .1325 | 1.131 | 3.4470 | 0.000 | 1.208 | 5.4979 | 1.285 | 7.6815 |
| 1.055 | 1.4270 | .1348 | 1.132 | 3.4733 | 0.000 | 1.209 | 5.5239 | 1.286 | 7.7116 |
| 1.056 | 1.4536 | .1373 | 1.133 | 3.5008 | 0.000 | 1.210 | 5.5506 | 1.287 | 7.7417 |
| 1.057 | 1.4802 | .1395 | 1.134 | 3.5282 | 0.000 | 1.211 | 5.5786 | 1.288 | 7.7718 |
| 1.058 | 1.5068 | .1418 | 1.135 | 3.5565 | 0.000 | 1.212 | 5.6071 | 1.289 | 7.8019 |
| 1.059 | 1.5334 | .1441 | 1.136 | 3.5842 | 0.000 | 1.213 | 5.6360 | 1.290 | 7.8320 |
| 1.060 | 1.5600 | .1464 | 1.137 | 3.6160 | 0.000 | 1.214 | 5.6651 | 1.291 | 7.8621 |
| 1.061 | 1.5870 | .1487 | 1.138 | 3.6437 | 0.000 | 1.215 | 5.6942 | 1.292 | 7.8922 |
| 1.062 | 1.6143 | .1510 | 1.139 | 3.6716 | 0.000 | 1.216 | 5.7233 | 1.293 | 7.9223 |
| 1.063 | 1.6414 | .1533 | 1.140 | 3.7000 | 0.000 | 1.217 | 5.7522 | 1.294 | 7.9524 |
| 1.064 | 1.6688 | .1556 | 1.141 | 3.7281 | 0.000 | 1.218 | 5.7814 | 1.295 | 7.9825 |
| 1.065 | 1.6959 | .1579 | 1.142 | 3.7563 | 0.000 | 1.219 | 5.8108 | 1.296 | 8.0126 |
| 1.066 | 1.7229 | .1602 | 1.143 | 3.7840 | 0.000 | 1.220 | 5.8401 | 1.297 | 8.0427 |
| 1.067 | 1.7496 | .1625 | 1.144 | 3.8119 | 0.000 | 1.221 | 5.8690 | 1.298 | 8.0728 |
| 1.068 | 1.7764 | .1647 | 1.145 | 3.8398 | 0.000 | 1.222 | 5.8982 | 1.299 | 8.1029 |
| 1.069 | 1.8033 | .1670 | 1.146 | 3.8677 | 0.000 | 1.223 | 5.9274 | 1.300 | 8.1330 |
| 1.070 | 1.8300 | .1693 | 1.147 | 3.8955 | 0.000 | 1.224 | 5.9568 | | |
| 1.071 | 1.8571 | .1716 | 1.148 | 3.9235 | 0.000 | 1.225 | 5.9861 | | |
| 1.072 | 1.8843 | .1738 | 1.149 | 3.9516 | 0.000 | 1.226 | 6.0061 | | |
| 1.073 | 1.9116 | .1761 | 1.150 | 3.9801 | 0.000 | 1.227 | 6.0361 | | |
| 1.074 | 1.9393 | .1783 | 1.151 | 4.0070 | 0.000 | 1.228 | 6.0662 | | |
| 1.075 | 1.9653 | .1806 | 1.152 | 4.0343 | 0.000 | 1.229 | 6.0925 | | |
| 1.076 | 1.9928 | .1828 | 1.153 | 4.0611 | 0.000 | 1.230 | 6.1206 | | |

for home use in their massive appearance, the sides of the bits being carved into various designs, and the rowels of the spurs are made enormously large. When bits are to be plated with metal they are tinned, and a piece of metal of sufficient thickness is wrapt or bent round it by pressure; this is aided by pressing down upon them with burnishers, &c. When the covering has been made to adhere very closely, the whole is heated, tin solder is applied, and the two become united: the final polish is given by the friction of buff leather and powdered burnt rotten-stone.

SAFFLOWER. This dye-stuff has been fully described under **CARTHAMUS** and **ROUGE**.

Landings, Deliveries, and Stocks of Safflower.

| | Landed. | Delivered. | Stock 1st January. |
|-------------------|---------|------------|--------------------|
| | Bales. | Bales. | Bales. |
| In December 1851 | 913 | 331 | — |
| 1850 | 1,176 | 465 | — |
| In 12 months 1851 | 4,431 | 4,701 | 2,990 |
| 1850 | 5,065 | 3,266 | 3,260 |
| 1849 | 3,756 | 3,529 | 1,461 |
| 1848 | 2,667 | 2,269 | 1,254 |

Prices, January, 1852, fine, *6l. 5s.* to *7l. 10s.* per cwt.; middling, *4l. 5s.* to *5l. 10s.*; ordinary, *2l.* to *3l. 10s.*

SAFFRON (*Saffran*, Fr. and Germ.); is a filamentous cake, composed of the stigmata of the flowers of the *Crocus sativus*. It contains a yellow matter called *polychroïte*, because a small quantity of it is capable of colouring a great body of water. This is obtained by evaporating the watery infusion of saffron to the consistence of an extract, digesting the extract with alcohol, and concentrating the alcoholic solution. The polychroïte remains in the form of a brilliant mass, of a reddish yellow colour, transparent, and of the consistence of honey. It has the agreeable smell, with the bitter pungent taste, of saffron. It is very soluble in water; and if it be stove-dried, it deliquesces speedily in the air. According to M. Henry père, polychroïte consists of 80 parts of colouring matter, combined with 20 parts of a volatile oil, which cannot be separated by distillation till the colouring matter has been combined with an alkali. By mixing 1 part of shred saffron with 8 parts of saturated brine, and $\frac{1}{2}$ part of caustic-lye, and distilling the mixture, the oil comes over into the receiver, and leaves the colouring matter in the retort, which may be precipitated from the alkaline solution by an acid. The pure colouring matter, when dried, is of a scarlet hue, and then readily dissolves in alcohol, as also in the fat and volatile oils, but sparingly in water. Light blanches the reddish-yellow of saffron, even when it is contained in a full phial well corked. Polychroïte, when combined with fat oils, and subjected to dry distillation, affords ammonia, which shows that azote is one of its constituents. Sulphuric acid colours the solution of polychroïte indigo blue, with a lilac cast; nitric acid turns it green, of various shades, according to the state of dilution. Protochloride (muriate) of tin produces a reddish precipitate.

Saffron is employed as a seasoning in French cookery. It is also used to tinge confectionery articles, liqueurs, and varnishes; but rarely as a pigment.

SAGO (*Sagou*, Fr. and Germ.); is a species of starch, extracted from the pith of the sago palm, a tree which grows to the height of 30 feet in the Moluccas and the Philippines. The tree is cut down, cleft lengthways, and deprived of its pith, which being washed with water upon a sieve, the starchy matter comes out, and soon forms a deposit. This is dried to the consistence of dough, pressed through a metal sieve to corn it (which is called *pearling*), and then dried over a fire with agitation in a shallow copper pan. Sago is sometimes imported in the pulverulent state, in which it can be distinguished from arrow-root only by microscopic examination of its particles. These are uniform and spherical, not unequal and ovoid, like those of arrow-root. See **PEPPER**.

SAL AMMONIAC. The manufacture of this salt may be traced to the remotest era. Its name is derived from Ammon, or the temple of Jupiter Ammon, in Egypt, near to which the salt was originally made. Sal ammoniac exists ready formed in several animal products. The dung and urine of camels contains a sufficient quantity to have rendered its extraction from them a profitable Egyptian art in former times, in order to supply Europe with the article. In that part of Africa, fuel being very scarce, recourse is had to the dung of these animals, which is dried for that purpose, by plastering it upon the walls. When this is afterwards burned in a peculiar kind of furnace, it exhales a thick smoke, replete with sal ammoniac in vapour; the soot of coarse contains a portion of

out especially in the Delta, peasants are seen driving asses loaded with bags of that soot, on their way to the sal ammoniac works.

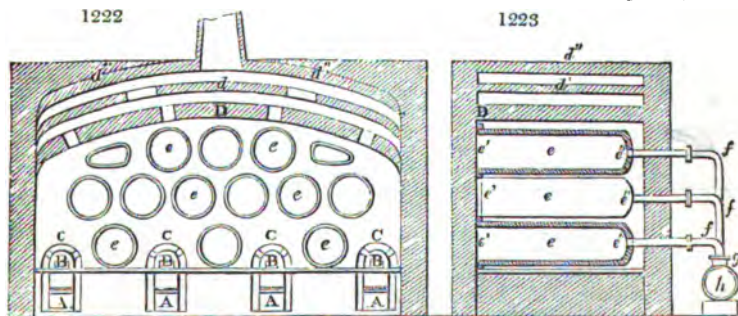
Here it is extracted in the following manner. Glass globes coated with loam are filled with the soot pressed down by wooden rammers, a space of only two or three inches being left vacant, near their mouths. These globes are set in round orifices formed in the ridge of a long vault, or large horizontal furnace flue. Heat is gradually applied by a fire of dry camels' dung, and it is eventually increased till the globes become obscurely red. As the muriate of ammonia is volatile at a temperature much below ignition, it rises out of the soot in vapour, and gets condensed into a cake upon the inner surface of the top of the globe. A considerable portion, however, escapes into the air; and another portion concretes in the mouth, which must be cleared from time to time by an iron rod. Towards the end, the obstruction becomes very troublesome, and must be most carefully attended to and obviated, otherwise the globes would explode by the uncondensed vapours. In all cases, when the subliming process approaches to a conclusion, the globes crack or split; and when they come to be removed, after the heat has subsided, they usually fall to pieces. The upper portion of the mass is separated, because to it the white salt adheres; and on detaching the pieces of glass with a hatchet, it is ready for the market. At the bottom of each balloon a nucleus of salt remains, surrounded with fixed pulverulent matter. This is reserved, and after being bruised, is put in along with the charge of soot in a fresh operation.

The sal ammoniac obtained by this process is dull, spongy, and of a grayish hue; but nothing better was for a long period known in commerce. Fifty years ago, it fetched 2s. 6d. a pound; now, perfectly pure sal ammoniac may be had at one-fifth part of that price.

Various animal offals develop during their spontaneous putrefactive fermentation, or their decomposition by heat, a large quantity of free or carbonated ammonia, among their volatile products. Upon this principle many sal ammoniac works have been established. In the destructive distillation of pitcoal, there is a considerable quantity of ammoniacal products, which are also worked up into sal ammoniac.

The first attempts made in France to obtain sal ammoniac profitably in this manner failed. A very extensive factory of the kind, which experienced the same fate, was under the superintendance of the celebrated Baumé, and affords one out of a thousand instances where theoretical chemists have shown their total incapacity for conducting operations on the scale of manufacturing economy. It was established at Gravelle near Charenton, and caused a loss to the shareholders in the speculation of upwards of 400,000 francs. This result closed the concern in 1787, after a foolish manipulation of 27 years. For ten years after that event, all the sal ammoniac consumed in France was imported into it from foreign countries. Since then the two works of MM. Payen and Pluvinet were mounted, and seem to have been tolerably successful. Coal soot was, prior to the introduction of the gas-works, a good deal used in Great Britain for obtaining sal ammoniac. In France, bones and other animal matters are distilled in large iron retorts, for the manufacture of both animal charcoal and sal ammoniac.

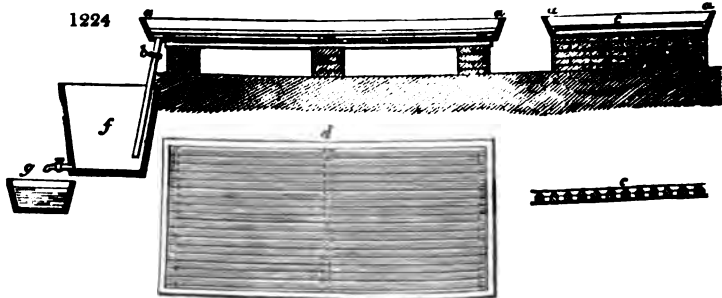
These retorts are iron cylinders, 2 or 3 feet in diameter, and 6 feet long. *Figs. 1222.*



and 1223. show the form of the furnace, and the manner in which the cylinders are arranged; the first being a longitudinal, the second a transverse section if it. A, the ash-pits under the grates; B, the fireplaces, arched over at top; C, the vault or bench of fire-bricks, perforated inside with eight flues for distributing the flame; D, a great arch, with a triple voissor *d, d', d''*, under which the retorts are set. The first arch *d*, is perforated with twenty vent-holes; the second, with four vent-holes; through which the flame passes to the third arch, and thence to the common chimney-stalks. The retorts *e*, are

shut by the door *d* (fig. 1223,) luted, and made fast with screw-bolts. Their other ends *e* terminate in tubes *f, f, f*, which all enter the main pipe *h*. The condensing pipe proceeds slantingly downwards from the further end of *h*, and dips into a large sloping iron cylinder immersed in cold water. See GAS-LIGHT and STOVZ, for a better plan of furnace.

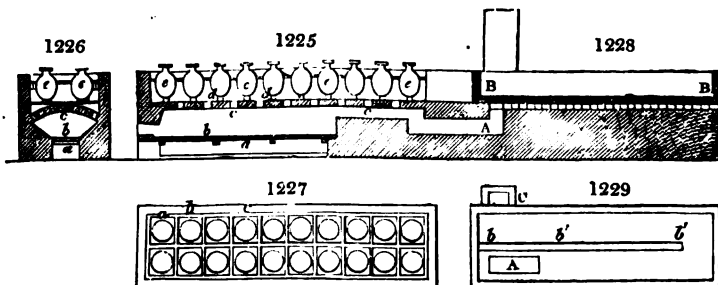
The filters used in the large sal ammoniac works in France are represented in fig. 1224. The apparatus consists—1. of a wooden chest *a*, lined with lead, and which is



turned over at the edges; a socket of lead *b*, soldered into the lowest part of the bottom serves to discharge the liquid; 2. of a wooden crib or grating formed of rounded rods as shown in the section *c, c*, and the plan *d*; this grating is supported one inch at least above the bottom, and set truly horizontal, by a series of wedges; 3. of an open fabric of canvas or strong calico, laid on the grating, and secured over the edges, so as to keep it tense. A large wooden reservoir *f*, lined with lead, furnished with a cover, is placed under each of the filters; a pump throws back once or twice upon the filters what has already passed through. A common reservoir *g*, below the others, may be made to communicate at pleasure with one of them, by means of intermediate stop-cocks.

The two boilers for evaporating and decomposing are made of lead, about one quarter of an inch thick, set upon a fire-brick vault, to protect them from the direct action of the flame. Through the whole extent of their bottoms above the vault, horizontal cast-iron plates, supported by ledges and brick compartments, compel the flame and burned air, as they issue from the arch, to percur many sinuosities before they pass up the chimney. This floor of cast iron is intended to support the bottom of the boiler, and to diffuse the heat more equably. The leaden boilers are surrounded with brick-work, and supported at their edges with a wooden frame. They may be emptied at pleasure into lower receivers, called crystallizers, by means of leaden syphons and long-necked funnels.

The crystallizers are wooden chests lined with lead, 15 inches deep, 3 or 4 feet broad, and from 6 to 8 feet long; and may be inclined to one side at pleasure. A round cistern receives the drainings of the mother-waters. The pump is made of lead, hardened with antimony and tin.



The subliming furnace is shown in figs. 1225, & 1226, by a transverse and longitudinal section. *a* is the ash-pit; *b*, the grate and fireplace; *c*, the arch above them. This arch, destined to protect the bottles from the direct action of the fire, is perforated with vent-holes, to give a passage to the products of combustion between the subliming vessels. *d, d*, are bars of iron, upon which the bottoms of the bottles rest; *e*, stoneware bottles, protected by a coating of loam from the flame.

Fig. 1227. shows the cast-iron plates, *a, b, c*, which, placed above the vaults, receive each two bottles in a double circular opening.

At the extremity of the above furnace, a second one, called the drier, *fig. 1228.*, receives the products of the combustion of the first, at *A*, under horizontal cast-iron plates, and upon which the bottom of a rather shallow boiler rests. After passing twice under these plates, round a longitudinal brick partition *b, b', b''*, the products of combustion enter the smoke chimney *c*. See plan, *fig. 1229*.

The boiler set over, this furnace should have no soldered joints. It may be $3\frac{1}{2}$ feet broad, 9 or 10 feet long, and 1 foot deep. The concrete sal ammoniac may be crushed under a pair of edge mill-stones, when it is to be sold in powder.

Bones, blood, flesh, horns, hoofs, woollen rags, silk, hair, scrapings of hides and leather, &c., may be distilled for procuring ammonia. When bones are used, the residuum in the retort is bone black. The charcoal from the other substances will serve for the manufacture of prussian blue. The bones should undergo a degree of calcination beyond what the ammoniacal process requires, in order to convert them into the best bone black; but the other animal matters should not be calcined up to that point, otherwise they are of little use in the prussian blue works. If the bones be calcined, however, so highly as to become glazed, their decolouring power on syrups is nearly destroyed. The other substances should not be charred beyond a red-brown heat.

The condensed vapours from the cylinder retorts afford a compound liquor holding carbonate of ammonia in solution, mixed with a large quantity of empyreumatic oil, which floats at top. Lest incrustations of salt should at any time tend to obstruct the tubes, a pipe should be inserted within them, and connected with a steam boiler, so as to blow steam through them occasionally.

The whole liquors mixed have usually a density of 8° or 9° Baumé (1.060). The simplest process for converting their carbonate of ammonia into muriate, is to saturate them with muriatic acid, to evaporate the solution in a leaden boiler till a pellicle appears, to run it off into crystallizers, and to drain the crystals. Another process is, to decompose the carbonate of ammonia, by passing its crude liquor through a layer of sulphate of lime, 3 or 4 inches thick, spread upon the filters, *fig. 1224*. The liquor may be laid on with a pump; it should never stand higher than 1 or 2 inches above the surface of the bruised gypsum, and it should be closely covered with boards, to prevent the dissipation of the volatile alkali in the air. When the liquor has passed through the first filter, it must be pumped upon the second; or the filters being placed in a terrace form, the liquor from the first may flow down upon the second, and thus in succession. The last filter should be formed of nearly fresh gypsum, so as to ensure the thorough conversion of the carbonate into sulphate. The resulting layers of carbonate of lime should be washed with a little water, to extract the sulphate of ammonia interposed among its particles. The ammoniacal liquor thus obtained must be completely saturated, by adding the requisite quantity of sulphuric acid; even a slight excess of acid can do no harm. It is then to be evaporated, and the oil must be skimmed off in the course of the concentration. When the liquid sulphate has acquired the density of about 1.160, sea salt should be added, with constant stirring, till the whole quantity equivalent to the double decomposition be introduced into the lead boiler.

The fluid part must now be drawn off by a syphon into a somewhat deep reservoir, where the impurities are allowed to subside; it is then evaporated by boiling, till the sulphate of soda falls down in granular crystals, as the result of the mutual reaction of the sulphate of ammonia and muriate of soda; while the more soluble muriate of ammonia remains in the liquor. During this precipitation, the whole must be occasionally agitated with wooden paddles; the precipitate being in the intervals removed to the cooler portion of the pan, in order to be taken out by copper rakes and shovels, and thrown into draining-hoppers, placed near the edges of the pan. The drained sulphate of soda must be afterwards washed with cold water, to extract all the adhering sal ammoniac.

The liquor thus freed from the greater part of the sulphate, when sufficiently concentrated, is to be drawn off by a lead syphon into the crystallizers, where, at the end of 20 or 30 hours, it affords an abundant crop of crystals of sal ammoniac. The mother-water may then be run off, the crystallizers set aslope to drain the salt, and the salt itself must be washed, first by a weak solution of sal ammoniac, and lastly with water. It must be next desiccated, by the apparatus *fig. 1228.*, into a perfectly dry powder, then put into the subliming stoneware balloons, by means of a funnel, and well rammed down. The mouth of the bottle is to be closed with a plate or inverted pot of any kind. The fire must be nicely regulated, so as to effect the sublimation of the pure salt from the under part of the bottle, with due regularity, into a white cake in the upper part. The neck of the bottle should be cleared from time to time with a long steel skewer, to prevent the risk of choking, and consequent bursting; but in spite of every precaution, several of the bottles crack almost in every operation. In Scotland, sal ammoniac is sublimed in cast-iron pots lined with thin fire-tiles, made in segments accommodated to

the internal surface of the pots; the vapour being received and condensed into cakes, within balloons of green glass set over their mouths. The salt, when taken out, and freed by scraping from any adhering ochreous or other impurities, is ready for the market, being sold in hollow spherical masses. The residuum in the pots or bottles may be partially worked up in another operation. The greatest evil is produced by the mixture or even contact of iron, because its peroxide readily rises in vapour with the sal ammoniac, and tinges it of a red or yellow colour.

The most ordinary process for converting the ammoniacal liquor of the gas-works into sal ammoniac, is to saturate it with sulphuric acid, and to decompose the sulphate, thus formed, by the processes above described. But muriatic acid will be preferred, where it is as cheap as sulphuric of equivalent saturating power; because a tolerably pure sal ammoniac is thereby directly obtained. As the coal-gas liquor contains a good deal of sulphuretted hydrogen, the saturation of it with acid should be so conducted as to burn the disengaged noxious gases in a chimney. Formerly human urine was very extensively employed, both in this country and in France, in the manufacture of sal ammoniac; but since the general establishment of gas-works it has been, I believe, abandoned. The process was exceedingly offensive.

The best white sal ammoniac is in spheroidal cakes of about one foot diameter, three or four inches thick in the middle, somewhat thinner at the edges, and is semi-transparent or translucent. Each lump weighs about one quarter of a cwt. As it is easily volatilized by heat, it may be readily examined as to its sophistication with other salts. Sal ammoniac has a certain tenacity, and is flexible under the hammer or pestle. It is principally used in tinning of cast-iron, wrought-iron, copper, brass, and for making the various ammoniacal preparations of pharmacy.

In a chemical factory near Glasgow, 7200 gallons of ammoniacal liquor, obtained weekly from the gas-works, are treated as follows:—The liquor is first rectified by distillation from a waggon-shaped wrought-iron boiler, into a square cistern of iron lined with lead. 4500 lbs. of sulphuric acid, of specific gravity 1.625, are then slowly added to the somewhat concentrated distilled water of ammonia. The produce is 2400 gallons of sulphate of ammonia, slightly acidulous, of specific gravity 1.150, being of such strength as to deposit a few crystals upon the sides of the lead-lined iron tank in which the saline combination is made. It is decomposed by common salt.

From the 7200 gallons of the first crude liquor, 900 gallons of tar are got by subsidence, and 200 gallons of petroleum are skimmed off the surface. The tar is converted, by a moderate boiling in iron pans, into good pitch.

A patent was obtained in 1840, for improvements in the manufacture of this article by Mr. H. Waterton. Two modes of operating are described; the first consists in making a saturated solution of common salt in water, and mixing with it a quantity of finely pulverised carbonate of ammonia, about equal in weight to the salt contained in the solution. The mixture is agitated in a close vessel for six or eight hours, and as much carbonic gas is infused therein as it will absorb (but the introduction of the gas is not absolutely necessary, although the patentee prefers it); the liquid is then separated from the solid matter by filtration and pressure. The solid matter is chiefly bi-carbonate of soda, and the liquid holds in solution muriate and carbonate of ammonia, and common salt, and sometimes a small portion of the bi-carbonate of soda.

The liquid is now placed in a distilling vessel, and the carbonate of ammonia being distilled over into a suitable receiver, a solution of muriate of ammonia and common salt remains in the still. This solution is evaporated, by heat, to such a consistency as will cause the separation of the common salt, by crystallisation, and the salt, thus crystallised, is evaporated from the liquid by any convenient method. The liquid is then evaporated until it attains the proper specific gravity for crystallising, and it is transferred into suitable utensils for that purpose. The crystals, produced by these means, are nearly pure muriate of ammonia, and then pressed and dried may be brought to market without further preparation, or they may be sublimed into cake sal ammoniac.

The other mode of manufacturing sal ammoniac consists in taking a quantity of liquid, containing ammonia, either in the caustic state, or combined with carbonic, hydrosulphuric, or hydrocyanic acid (such as gas ammoniacal liquor, or bone ammoniacal liquor), and rectifying it, by distillation, until the distilled portion contains from twenty to twenty-five per cent. of carbonate of ammonia. If the liquid contains any other acids than those above mentioned, a sufficient quantity of lime is used in the distillation to decompose the ammoniacal salt.

The distilled liquid being now mixed with as large a quantity of powdered common salt as it will dissolve, is agitated for several hours, and as much carbonic acid gas is infused into it as it will absorb. The remainder of the operation is the same as before described in the first method of manufacturing sal ammoniac. — *Newton's Journal*, C. S. xxii. 35.

SALAMSTONE. . See LAPIDARY.

SALEP, or SALOUP, is the name of the dried tuberous roots of the *Orchis*, imported from Persia and Asia Minor, which are the product of a great many species of the plant, but especially of the *Orchis mascula*. Salep occurs in commerce in small oval grains, of a whitish-yellow colour, at times semi-transparent, of a horny aspect, very hard, with a faint peculiar smell, and a taste like that of gum tragacanth, but slightly saline. These are composed almost entirely of starchy matter, well adapted for making a thick pap with water or milk, and are hence in great repute in the Levant, as restorers of the animal forces. Their aphrodisiacal properties are apocryphal. If the largest roots of the *Orchis mascula* of our own country were cleaned, scraped, steeped for a short time in hot, and then for a few minutes in boiling water, to extract their rank flavour, afterwards suspended upon strings to dry in the air, they would afford as nourishing and palatable an article as the Turkey saloup, and at a vastly lower price.

SALICINE, is a febrifuge substance, which may be obtained in white pearly crystals from the bark of the white willow (*Salix alba*), of the aspen tree (*Salix helix*), as also of some other willows, and some poplars. It has a very bitter taste.

SAL PRUNELLA, is fused nitre cast into cakes or balls.

SAL VOLATILE, is sesquicarbonate of ammonia.

SALT, EPSOM, is sulphate of magnesia.

SALT, MICROCOSMIC, is the triple phosphate of soda and ammonia.

SALT OF AMBER, is succinic acid.

SALT OF LEMONS, is citric acid.

SALT OF SATURN, is acetate of lead.

SALT OF SODA, is carbonate of soda.

SALT OF SORREL, is bi-oxalate of potassa.

SALT OF TARTAR, is carbonate of potassa.

SALT OF VITRIOL, is sulphate of zinc.

SALT PERLATE, is phosphate of soda.

SALTPETRE, is nitre, or nitrate of potassa, which see.

SALT SEDATIVE, is boracic acid.

SALTS, are an important class of chemical compounds, anciently studied under the Greek title of *Halurgy*. At one period every inorganic substance readily soluble in water, was regarded as a salt; and afterwards, every substance soluble in five hundred times its weight of water. Thus both acid and alkaline bodies came to be enrolled among salts; but latterly, the combinations of the acids with alkalis, earths, and metallic calces (now styled oxides), were alone thought to be entitled to the denomination of salts, in consequence of their resemblance in appearance, and supposed analogy in composition, to culinary salt. Since Sir H. Davy demonstrated that this substance contained neither acid nor alkaline matter, but that it consisted of chlorine and the metal sodium, the generality of chemists found it impossible to include salts under one category of constitution; while a few have rashly offered to cut the knot, by excluding from the saline family, chloride of sodium, the patriarch of the whole.

Salts, may be justly divided into three orders:

1. The binary, consisting of two single members; such as the bromides, chlorides, cyanides, fluorides, iodides, carburets, phosphurets, sulphurets, &c.

2. The bi-binary, consisting of two double members; such as the borates, bromates, carbonates, chlorates, sulphates, sulphites, hyposulphites, sulphodrydrates, &c.

3. The ternary, consisting of two single members of one genus and one member of another; such as the boro-fluorides, silico-fluorides, sulpho-cyanides, chlorides, &c.

The species of each order may exist in three states, constituting neutral salts; super-salts; and subsalts; as for example, the chloride of sodium, the subsulphate of potassa, the subnitrate of lead, &c.

In the above arrangement, cyanogen is allowed to represent a simple substance, from its forming analogous compounds with chlorine and iodine. The neutral state of salts is commonly indicated by their solutions not changing the colour of litmus, violets, or red cabbage; the sub-state of salts, by their turning the violet and cabbage green; and the super-state of salts, by their changing the purple of litmus, violets, and cabbage, red; but to the generality of this criterion there are some exceptions. The atomic theory may be advantageously resorted to in this predicament. 1. When one prime equivalent of the one member (whether single or double) of a salt, combines with one prime of the other member, a neutral salt is the result, as in chlorides of sodium or nitrate of potassa. 2. When two primes of the electro-negative member combine with one prime of the electro-positive, a supersalt is formed, as bichloride of tin, or bisulphate of potassa. 3. When one prime of the electro-negative member combines with two or more primes of the electro-positive, a sub-salt is produced, as the subacetate and subchromate of lead, &c.

SALT. The salt manufacture of Droitwich, Worcestershire, existed at a very early period: it is mentioned as in operation at the time of the Roman invasion; then it was

carried on in a primitive style, and at a considerable expense. The brine springs here extend over a very limited space of land, and are comprised within a circle of about 200 yards in diameter. Formerly the brine was obtained by boring. This process made it rise to the surface and run to waste; for in ascending through and mixing with the freshwater springs, it was very much lowered in strength, and the manufacture of the salt, which was conducted by evaporation, was attended with greater expense, owing to the quantity of fuel required to evaporise the water.

Within the last 50 years an improvement was effected by casing the pit with wood, and thus partially preventing the fresh water mixing with the brine. More recently the principle was introduced of sinking a shaft quite through the fresh water springs, and then making the bottom and sides of the pit secure with iron cylinders before boring down to the brine springs. By this means the brine is obtained at its full saturation, or about 42 parts of salt out of the 100; whereas, formerly, it varied between 28 and 37 per cent.

There has been recently obtained a patent for improvements in manufacturing salt; by using very large evaporating pans of an improved construction, larger quantities of salt are obtained, at a considerable saving of labour to the workmen, who obtain better wages and longer intervals of rest.

The source of the brine in Droitwich is inexhaustible, and exhibits no diminution of strength or quality; it lies at a depth of 173 feet from the surface, but as soon as it is reached by boring it rises to the level. The salt manufactured here is exported largely from the ports of London, Gloucester, and Bristol. There are upwards of 70,000 tons per annum manufactured, of which 40,000 tons are used for domestic and agricultural purposes; the rest is used chiefly for chemical decomposition and exportation. The Droitwich salt has always been celebrated for its strength and purity.

SALT, SEA or CULINARY. *Chloride of sodium; muriate of soda.* (*Hydrochlorate de soude, Fr.; Chloratrium, Germ.*) Sea salt, or rock salt, in a state of purity, consists of 60 of chlorine + 40 of sodium, in 100 parts.

This important species of the saline class possesses, even in mass, a crystalline structure, derived from the cube, which is its primitive form. It has generally a foliated texture, and a distinct cleavage; but it has also sometimes a fibrous structure. The massive salt has a vitreous lustre. It is not so brittle as nitre; it is nearly as hard as alum, a little harder than gypsum, and softer than calcareous spar. Its specific gravity varies from 2.0 to 2.25. When pure, it is colourless, translucent, or transparent. On exposure to heat, it commonly decrepitates; but some kinds of rock salt enter quietly into fusion at an elevated temperature, a circumstance which has been ascribed to their having been originally subjected to the action of fire.

According to M. Gay Lussac, 100 parts of water dissolve —

| | |
|---|---------------|
| 35.81 parts of the salt, at temperature | 57° 00' Fahr. |
| 35.88 — | 62.50 |
| 37.14 — | 140° 00' |
| 40.38 — | 229° 50' |

Native chloride of sodium, whether obtained from the waters of the ocean, from saline lakes, from salt springs, or mineral masses, is never perfectly pure. The foreign matters present in it vary with its different origins and qualities. These are, the sulphates of lime, magnesia, soda, muriates of magnesia and potash, bitumen, oxide of iron, clay in a state of diffusion, &c.

Muriate of potash has been detected in the waters of the ocean, in the sal-gem of Berchtesgaden in Bavaria, of Hallein in the territory of Salzburg, and in the salt springs of Rosenheim.

The more heterogeneous the salt, the more soluble is it, by the reciprocal affinity of its different saline constituents; and thus a delicate hydrometer, plunged in saturated brine, may serve to show approximately the quality of the salt. I find that the specific gravity of a saturated solution of large-grained cubical salt, is 1.1962 at 60° F. 100 parts of this brine contain 25½ of salt, (100 w. + 34.2 a.) From mutual penetration 100 volumes of the aqueous and saline constituents form rather less than 96 of the solution.

Among the varieties in the form of this salt, the octahedral, the cubo-octahedral, and the dodecahedral, have been mentioned; but there is another, called the funnel or hopper-shaped, which is very common. It is a hollow rectangular pyramid, which forms at the surface of the saline solution in the course of its evaporation, commencing with a small floating cube, upon which lines of other little cubes attach themselves to the edges of the upper face; whereby they form and enlarge the sides of a hollow pyramid, whose apex, the single cubic crystal, is downward. This sinks by degrees as the aggregation goes on above, till a pyramidal boat of considerable size is constructed.

A TABLE of the results of the ANALYSES of several varieties of CULINARY SALT.

| Origin of the Salt. | Chloride of Sodium. | Muriate of Magnesia. | Muriate of Lime. | Sulphate of Soda. | Sulphate of Magnesia. | Sulphate of Lime. | Clay and other insoluble bodies. | Oxide of Iron. |
|---------------------------------|---------------------|----------------------|------------------|-------------------|-----------------------|-------------------|----------------------------------|----------------|
| Sal-gem of Vie | white | 99.30 | — | — | — | 0.005 | 0.020 | |
| | red | 99.80 | — | — | — | — | 0.002 | |
| Cheshire, crushed | 98.33 | 0.02 | — | — | — | 0.65 | — | 0.002 |
| <i>Salt from Salt Springs :</i> | | | | | | | | |
| Schönbeck, Westphalia | 93.90 | 0.30 | — | 1.00 | — | 0.80 | | |
| Moutiers | des cordes | 97.17 | 0.25 | — | 2.00 | 0.58 | | |
| | boilers | 93.59 | 0.61 | — | 5.55 | 0.25 | | |
| Château Salins | 97.82 | 2.12 | — | — | — | — | | |
| White of Sulz | 96.88 | 3.12 | — | — | — | — | | |
| Ludwigshall, middle grained | 99.45 | — | — | 0.05 | — | 0.28 | | |
| Königsborn, Westphalia | 95.90 | — | 0.27 | — | — | 1.10 | | |
| Sea salt, half white | 97.20 | 0.004 | — | — | 0.050 | 0.120 | 0.070 | |
| —, of Saint Malo | 96. | 0.30 | — | — | 0.45 | 2.35 | | |
| Common Scottish salt | 93.55 | 2.80 | — | — | 1.75 | 1.50 | | |
| Lymington, common | 93.7 | 1.1 | — | — | 3.50 | 1.50 | 2.00 | |
| —, cat | 98.8 | 0.5 | — | — | 0.5 | 0.1 | | |
| Cheshire, stoved | 98.25 | 0.075 | 0.025 | — | — | 1.55 | | |

The geological position of rock salt is between the coal formation and the lias. The great rock-salt formation of England occurs within the *red marl*, or new red sandstone, the *bunter-sandstein* of the Germans, so called, because its colours vary from red to salmon and chocolate. This mineral stratum frequently presents streaks of light blue, verdigris, buff, or cream colour; and is chiefly remarkable for containing considerable masses or beds of gypsum. At Northwich, in the vale of the Weaver, the rock salt consists of two beds, together not less than 60 feet thick, which are supposed to constitute large insulated masses, about a mile and a half long, and nearly 1300 yards broad. There are other deposits of rock salt in the same valley, but of inferior importance. The uppermost bed occurs at 75 feet beneath the surface, and is covered with many layers of indurated red, blue, and brown clay, interstratified more or less with sulphate of lime, and interspersed with argillaceous marl. The second bed of rock salt lies 31½ feet below the first, being separated from it by layers of indurated clay, with veins of rock salt running through them. The lowest bed of salt was excavated to a depth of 110 feet, several years ago.

The beds or masses of rock salt are occasionally so thick, that they have not been yet bored through, though mined for many centuries. This is the case with the immense mass of Wieliczka, and the lower bed at Northwich. But in ordinary cases, this thickness varies from an inch or two to 12 or 15 yards. When the strata are thin, they are usually numerous; but the beds, layers, or masses never exhibit throughout a great extent any more than an illusory appearance of parallelism; for when they are explored at several points, enlargements are observed, and such diminutions as cause the salt to disappear sometimes altogether. This mineral is not deposited, therefore, in a geological stratum, but rather in lenticular masses, of very variable extent and thickness, placed alongside of each other at unequal distances, and interposed between the courses of the other formations.

Sometimes the rock salt is disseminated in small masses or little veins among the calcareous and argillaceous marls which accompany or overlie the greater deposits. Bitumen, in small particles, hardly visible, but distinguishable by the smell, occurs in all the minerals of the saliferous system.

It has been remarked, that the plants which grow generally on the sea shores, such as the *Triglochin maritimum*, the *Salicornia*, the *Salsola kali*, the *Aster trifolium*, or farwell to summer, the *Glaux maritima*, &c., occur also in the neighbourhood of salt mines and salt springs, even of those which are most deeply buried beneath the surface.

The interior of rock-salt mines, after digging through the strata of clay marl, &c. is extremely dry; so that the dust produced in the workings becomes an annoyance to the miners, though in other respects the excavations are not at all insalubrious.

Salt springs occur nearly in the same circumstances, and in the same geological form-

ation as the salt rock. It has been noticed that salt springs issue, in general, from the upper portion of the saliferous strata, principally from the saline clay marls. Cases however occur, where the salt springs are not accompanied by rock salt, and where the whole saline matter is derived from the marls themselves, which thus constitute the only saliferous beds.

It has been imagined that there are two other periods of geological formation of this substance; one much more antient, belonging to the transition series of rocks; the other relatively modern, among secondary strata. To the former has been referred the salt formation of Bex, that of Cardonne, &c. But M. Brongniart assigns valid reasons for rejecting this supposition. M. Beudant, indeed, refers to the secondary strata above the chalk, the rock-salt formation of Wieliczka, and of the base of the Carpathians; placing these among the plastic clay and lignites.

The mines of rock salt do not appear to possess any determinate elevation upon the surface of the earth. Immense masses of it are met with at very great depths below the level of the sea, (the mine of Wieliczka is excavated 860 feet beneath the soil,) and others exist at a considerable altitude, as that of Hallein near Salzburg, which is 3900 feet above the level of the sea, and the saline rock of Arbonne in Savoy, which is nearly 4000 feet higher, situated at the great elevation of 7200 feet above the level of the sea, and consequently in the region of perpetual snow. The rock is a mass of saccharoid and anhydrous gypsum, imbued with common salt, which is extracted by lixiviation; after which the gypsum remains porous and light.

The inland seas, salt lakes, and salt marshes, have their several localities obviously independent of peculiar geological formations. The ocean is, however, the most magnificent mine of salt, since this chloride constitutes about one-thirtieth part of its weight; being pretty evenly diffused throughout its waters, when no local cause disturbs the equilibrium. The largest proportion of salt held in solution in the open sea, is 38 parts in 1000, and the smallest 32. In a specimen taken by Mr. Wilkinson, out of the Red Sea, at Berenice, I found 43 parts of salt in 1000. The specific gravity of the water was 1.035.

Were it requisite to extract the chloride of sodium from sea-water by fuel alone, many countries, even maritime, would find the process too costly. The salt is therefore obtained from it in two different manners; 1. by natural evaporation alone; 2. by natural and artificial evaporation combined. The first method is employed in warm regions, under the form of saline tanks, or brine reservoirs, called also brine-pits. These are large shallow basins, the bottom of which is very smooth, and formed of clay. They are excavated along the sea-shore, and consist of—

1st. A large reservoir, deeper than the proper brine-pits, which is dug between them and the sea. This reservoir communicates with the sea by means of a channel provided with a sluice. On the sea-shore, these reservoirs may be filled at high water, though the tides are rather inconvenient than advantageous to brine-pits.

2dly. The brine-pits, properly so called, which are divided into a number of compartments by means of little banks. All these compartments have a communication with each other, but so that the water frequently has a long circuit to make, from one set to another. Sometimes it must flow 400 or 500 yards, before it reaches the extremity of this sort of labyrinth. The various divisions have a number of singular names, by which they are technically distinguished. They should be exposed to the north, north-east, or north-west winds.

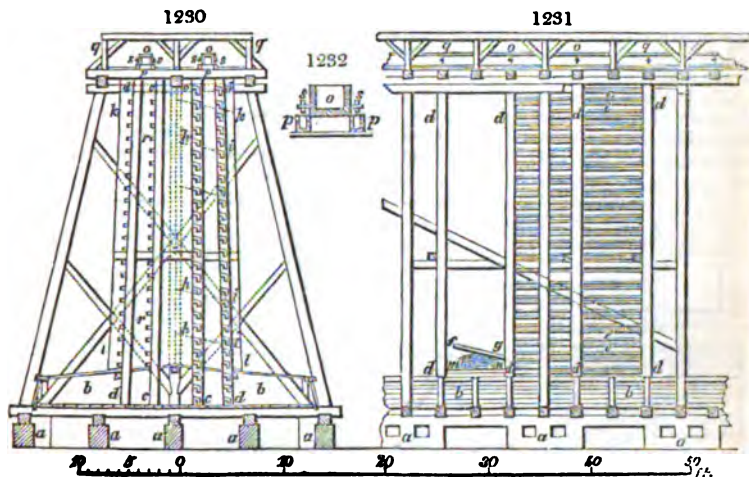
The water of the sea is let into these reservoirs in the month of March, where it is exposed on a vast surface to evaporation. The first reservoir is intended to detain the water till its impurities have subsided, and from it the other reservoirs are supplied, as their water evaporates. The salt is considered to be on the point of crystallizing when the water begins to grow red. Soon after this, a pellicle forms on the surface, which breaks, and falls to the bottom. Sometimes the salt is allowed to subside in the first compartment; at others, the strong brine is made to pass on to the others, where a larger surface is exposed to the air. In either case the salt is drawn out, and left upon the borders to drain and dry.

The salt thus obtained, partakes of the colour of the bottom on which it is formed; and is hence white, red, or gray.

Sea water contains, in 1000 parts, 25 of chloride of sodium, 5.3 sulphate of magnesia, 3.5 chloride of magnesium, 0.2 carbonate of lime and magnesia, 0.1 sulphate of lime, besides $\frac{1}{1000}$ of sulphate and muriate of potash. It also contains iodide of sodium, and bromide of magnesium. Its average spec. grav. is from 1.029 to 1.030.

Sea-water and weak brines may be concentrated either by the addition of rock salt, by spontaneous evaporation in brine-pits (see *suprà*), or by graduation. Houses for the last purpose are extensively employed in France and Germany. The weak brine is pumped into an immense cistern on the top of a tower, and is thence allowed to flow down the surface of bundles of thorns built up in regular walls, between parallel wooden frames. At Salza, near Schönebeck, the graduation-house is 5817 feet long, the thorn

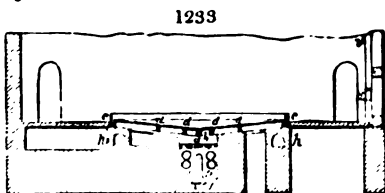
walls are from 33 to 52 feet high, in different parts, and present a total surface of 25,000 square feet. Under the thorns, a great brine cistern, made of strong wooden planks, is placed, to receive the perpetual shower of water. Upon the ridge of the graduation-house there is a long spout, perforated on each side with numerous holes, and furnished with spigots or stopcocks for distributing the brine, either over the surface of the thorns, or down through their mass; the latter method affording larger evaporation. The graduation-house should be built lengthwise in the direction of the prevailing wind, with its ends open. An experience of many years at Salza and Dürrenberg has shown, that in the former place graduation can go on 258, and in the latter 207 days, on an average, in the year; the best season being from May till August. At Dürrenberg, 3,596,561 cubic feet of water are evaporated annually. According to the weakness of the brine, it must be the more frequently pumped up, and made to flow down over the thorns in different compartments of the building, called the 1st, 2d, and 3d graduation. A deposit of gypsum incrusts the twigs, which requires them to be renewed at the end of a certain time. Figs. 1230, & 1231, represent the graduation-house of the salt-works at Dürrenberg. *a, a, a*, are low stone pillars for supporting the brine cistern *b*, called



the *soole-schiff*. *c, c* are the inner, *d, d* the outer, walls of thorns; the first have perpendicular sides, the last sloping. The spars *e, e*, which support the thorns, are longer than the interval between two thorn walls from *f* to *g*, fig. 1231, whereby they are readily fastened by their tenons and mortises. The spars are laid at a slope of 2 inches in the foot, as shown by the line *h, i*. The bundles of thorns are each $1\frac{1}{4}$ foot thick, from 5 to 7 feet long, and are piled up in the following way:— Guide-bars are first placed in the line *h, l*, to define the outer surface of the thorn wall, the undermost spars *m, n*, are fastened upon them; and the thorns are evenly spread, after the willow-withs of the bundles have been cut. Over the top of the thorn walls are laid, through the whole length of the graduation-house, the brine spouts *o, o*, which are secured to the upper beams; and at both sides of these spouts are the drop-spouts *p, p*, for discharging the brine by the spigots *s, s*, as shown upon a larger scale in fig. 1232. The drop-spouts are 6 feet long, have on each side small notches, 5 inches apart, and are each supplied by a spigot. The space above the ridge of the graduation-house is covered with boards, supported at their ends by binding-beams *q*. *r, r* show the tenons of the thorn-spars. Over the *soole schiff*, inclined planes of boards are laid for conducting downwards the innumerable showers. The brine, which contains at first 7.692 per cent. of salt, indicates, after the first shower, 11.473; after the second, 16.108; and after the third, 22. The brine, thus concentrated to such a degree as to be fit for boiling, is kept in great reservoirs, of which the eight at Salza, near Schönebeck, have a capacity of 2,421,720 cubic feet, and are furnished with pipes leading to the sheet-iron salt-pans. The capacity of these is very different at different works. At Schönebeck there are 22, the smallest having a square surface of 400 feet, the largest of 1250, and are enclosed within walls, to prevent their being affected by the cold external air. They are covered with a funnel-formed or pyramidal trunk of deals, ending in a square chimney, to carry off the steam.

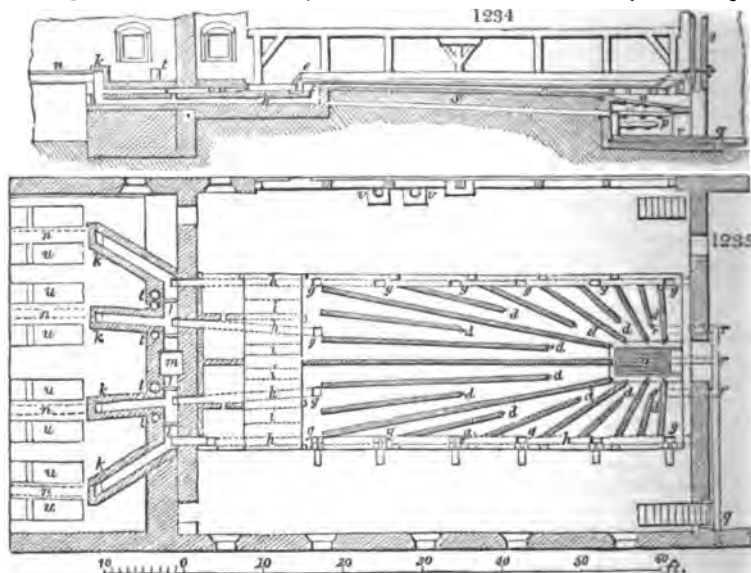
Figs. 1233, 34, 35, represent the construction of a salt-pan, its furnace, and the salt store-room of the works at Dürrenberg; fig. 1235, being the ground plan, fig. 1234.

the longitudinal section, and *fig.* 1233, the transverse section. *a* is the fire-grate, which slopes upwards to the back part, and is 31 $\frac{1}{2}$ inches distant from the bottom of the pan. The ratio of the surface of the grate to that of the bottom of the pan, is as 1 to 59.5; that of the air-hole into the ash-pit, as 1 to 306. The bed under the pan is laid with bricks, smoothly plastered over, from *b* to *e*, in *fig.* 1234. Upon this bed the pillars *d, d*, &c., are built in a radiated direction, being 6 inches broad at the bottom, and tapering to 1 $\frac{1}{2}$ inch at top. The pan is so laid that its bottom has a fall towards the middle of



2 $\frac{1}{2}$ inches: see *e, f, fig.* 1234. The fire diffuses itself in all directions under the pan, proceeds thence through several holes *g, g*, into flues *k, k, k*, which run round three sides of the pan; the burnt air then passes through *i, fig.* 1235, under other pans, from which it is collected in the chimneys *k, k*, to be conducted into the drying-room. At *l, l*, there is a transverse flue, through which, by means

of dampers, the fire-draught may be conducted into an extra chimney *m*. From the flues *k, k*, four square iron pipes *n, n*, issue and conduct the burnt air into the main chimneys in the opposite wall. The bottoms of the several flues have a gradual ascent above the level of the fire-grate. A special chimney *o*, rises above the ash-pit, to carry off the smoke, which may chance to regurgitate in certain states of the wind. *p, p*, are iron pipes laid upon each side of the ash-pit (see *figs.* 1234, & 1235.), into which cold air is admitted by the flue *q, r*,

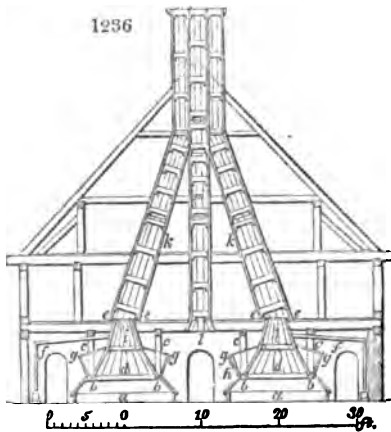


where, becoming heated, it is conducted through iron pipes *s*, and thence escapes at *t*, into the stove-room. Upon both sides of the hot flues in the stove-room, hurdle-frames *u, u*, are laid, each of which contains 11 baskets, and every basket, except the undermost, holds 60 pounds of salt, spread in a layer 2 inches thick. *v, v*, show the pipes by which the pan is supplied with graduated brine.

Description of the Steam-trunk, in fig. 1236.

In front of the pan *a, a*, there are two upright posts, upon which, and in holes of the back wall, two horizontal beams *b, b*, are supported. The pillars *c, c*, are sustained upon the bearers *d, d*. At *e, e*, a deep quadrangular groove is made in the beams, for fixing down the four boards which form the bottom of the steam-way. In this groove any condensed water from the steam collects, and is carried off by a pipe *f*, to prevent it falling back into the pan. Upon the three sides of the pan not in contact with the wall, there are three rows of boards hinged upon planks *b, b*. Behind the upper one, a board is hung on at *g*, upon which the boiled salt is laid to drain. The

two other rows of boards are hooked on so as to cover the pan, as shown at *h*. Whenever the salt is sufficiently drained, the upper shelves are placed in a horizontal position; the salt is put into small baskets, and carried into the stove-room. *i, k*, is the steam-trunk; *l, m*, is a tunnel for carrying off the steam from the middle of the pan, when this is uncovered by lifting the boards.



In proportion as the brine becomes concentrated by evaporation, more is added from the settling reservoir of the graduation-house, till finally small crystals appear on the surface. No more weak brine is now added, but the charge is worked off, care being taken to remove the scum as it appears. In some places the first pan is called a schlot-plan, in which the concentration is carried only so far as to cause the deposition of the sludge, from which the saline solution is run into another pan, and gently evaporated, to produce the precipitation of the fine salt. This salt should be continually raked towards the cooler and more elevated sides

of the pan, and then lifted out with cullender-shovels into large conical baskets, arranged in wooden frames round the border of the pan, so that the drainage may flow back into the boiling liquor. The drained salt is transferred to the hurdles or baskets in the stove-room, which ought to be kept at a temperature of from 120° to 130°, Fahr. The salt is then stowed away in the warehouse.

The graduation range should be divided lengthwise into several sections: the first to receive the water of the spring, the lake, or the sea; the second, the water from the first shower-receiver; the third, the water from the second receiver; and so on. The pumps are usually placed in the middle of the building, and lift the brine from the several receivers below into the alternate elevated cisterns. The square wooden spouts of distribution may be conveniently furnished with a slide-board, attached to each of their sides, to serve as a general valve for opening or shutting many trickling orifices at once. The rate of evaporation at Moutiers is exhibited by the following table:—

| Number of Showers. | Total Surface of the Fagots. | Specific Gravity of the Brine. | Water evaporated. |
|--|------------------------------|--------------------------------|-------------------|
| 1 and 2 - - - | 5158 square feet - - | 1·010 | 0·000 |
| 3, 4, 5, 6, 7, 8, and 9 - | 2720 - - - | 1·023 | 0·540 |
| 10 - - - | 550 - - - | 1·072 | 0·333 |
| | | 1·140 | 0·062 |
| Total evaporation - - - | | | 0·935 |
| Water remaining in the brine at the density of 1·140 - - | | | 1·065 |
| Water assigned at the density of 1·010 - - - | | | 1·000 |

From the above table it appears that no less than 10 falls of the brine have been required to bring the water from the specific gravity 1·010 to 1·140, or 18° Baumé. The evaporation is found to proceed at nearly the same rate with the weaker water, and with the stronger, within the above limits. When it arrives at a density of from 1·140 to 1·16, it is run off into the settling cisterns. M. Berthier calculates, that upon an average, in ordinary weather, at Moutiers, 60 kilogrammes of water (13 gallons, imp.) are evaporated from the fagots, in the course of 24 hours, for every square foot of their surface. Without the aid of currents of air artificially warmed, such an amount of evaporation could not be reckoned upon in this country. In the *schlotting*, or throwing down of the sediment, a little bullock's blood, previously beaten up with some cold brine, promotes the clarification. When the brine acquires, by brisk ebullition, the density of 1·200, it should be run off from the preparation, to the finishing or salting pans.

The mother-water contains a great deal of chloride of magnesium, along with chloride of sodium, and sulphate of magnesia. Since the last two salts mutually decompose each other at a low temperature, and are transformed into sulphate of soda, which crystallizes, and muriate of magnesia, which remains dissolved, the mother-water with

this view may be exposed in tanks to the frost during winter, when it affords three successive crystalline deposits, the last being sulphate of soda, nearly pure.

The chloride of magnesium, or bittern, not only deteriorates the salt very much, but occasions a considerable loss of weight. It may, however, be most advantageously got rid of, and converted into chloride of sodium by the following simple expedient:—Let quicklime be introduced in equivalent quantity to the magnesia present, and it will precipitate this earth, and form chloride of calcium, which will immediately react upon the sulphate of soda in the mother-water, with the production of sulphate of lime and chloride of sodium. The former being sparingly soluble, is easily separated. Lime, moreover, decomposes directly the chloride of magnesium, but with the effect of merely substituting chloride of calcium in its stead. But in general there is abundance of sulphate of soda in brine springs to decompose the chloride of calcium. A still better way of proceeding with sea-water would be to add to it, in the settling tank, the quantity of lime equivalent to the magnesia, whereby an available deposit of this earth would be obtained, at the same time that the brine would be sweetened. Water thus purified may be safely crystallized by rapid evaporation.

In summer, the saturated boiling brine is crystallized by passing it over vertical ropes; for which purpose 100,000 metres (110,000 yards) are mounted in an apartment 70 metres (77 yards) long. When the salt has formed a crust upon the ropes about $2\frac{1}{2}$ inches thick, it is broken off, allowed to fall upon the clean floor of the apartment, and then gathered up. The salting of a charge, which would take 5 or 6 days in the pan, is completed in this way in 17 hours; but the mother-waters are more abundant. The salt is, however, remarkably pure.

The boilers constructed at Rosenheim, in Bavaria, evaporate $3\frac{1}{2}$ pounds of water for every pound of wood burned; which is reckoned a favourable result; but some of those described under EVAPORATION would throw off much more.

"The rock salt mines and principal brine springs are in Cheshire; and the chief part of the Cheshire salt, both fossil and manufactured, is sent by the river Weaver to Liverpool, a very small proportion of it being conveyed elsewhere, by canal or land carriage. There are brine springs in Staffordshire, from which Hull is furnished with white salt; and in Worcestershire, from which Gloucester is supplied. If to the quantity shipped by the Weaver, 100,000 tons of white salt are added annually for internal consumption and exports, exclusive of Liverpool, the total manufacture will be approached very nearly; but as there is now no check from the excise, it is impossible to ascertain it exactly. Fossil salt is used in small quantities at some of the Cheshire manufactories, to strengthen the brine, but it is principally exported; some to Ireland, but chiefly to Belgium and Holland."* The average quantity of rock salt sent annually down the river Weaver, from the mines in Cheshire, between the years 1803 and 1834 inclusive, was 86,000 tons, of 2,600 lbs. each; the greatest being 125,658, in the year 1823, and the least 47,230, in the year 1813. The average quantity of white salt sent annually down the Weaver from the manufactories in Cheshire during the same period, was 221,351; the greatest being 383,669, in the year 1832, and the least being 190,486, in the year 1811.

M. Clement-Desormes, engineer and chief *actionnaire* of the great salt-works of Dieuze, in France, informed me that the internal consumption of that kingdom is rather more than 200,000 tons per annum, being at the rate of $6\frac{1}{2}$ kilogrammes for each individual of a population estimated at 32,000,000. As the retail price of salt in France is 10 sous per kilogramme (of $2\frac{1}{2}$ lbs. avoird.), while in this country it is not more than 2 sous (1 penny), its consumption per head will be much greater with us; and, taking into account the immense quantity of salted provisions that are used, it may be reckoned at 22 lbs.; whence our internal consumption will be 240,000 tons, instead of 100,000, as quoted above, from the tables published by the Board of Trade.

In 1836, 9,622,427 bushels, of 56 lbs. = 240,560 tons of salt, value 173,923*l.*, were exported from the United Kingdom, of which 1,350,849 bushels went to Russia; 1,235,086 to Belgium; 314,132 to the Western coast of Africa; 1,293,560 to the British North American colonies; 2,870,808 to the United States of America; 53,299 to New South Wales, Van Diemen's Land, and other Australian settlements; 58,735 to the British West Indies; and 90,655 to Guernsey, Jersey, Alderney and Man. The exports in 1850 were 15,819,664 bushels; in 1851, 18,265,693 bushels.

SALT WATER FRESHENED. Dr. Normandy and Mr. R. Fell have lately obtained a patent for the said purpose, which seems to work well. The apparatus consists of a vertical cylinder, having a series of horizontal partitions communicating each with the one below it, and each with a pipe leading to a condenser. A space is left between the sides of the cylinder and the partitions, to allow of steam circulating freely within the interior of the cylinder. The salt water to be freshened is introduced into the apparatus from the top, and circulates over the partitions, and the aqueous vapour

* Tables of the Revenue, Population, Commerce, &c., for 1835, p. 122.

arising from it passes off to the condenser, and on its way becomes mixed with atmospheric air, introduced through a suitable pipe, and issues from the condenser in an aerated state, while the water arising from the condensation of the steam admitted into the cylinder is discharged therefrom without being aerated. The apparatus may be constructed of any suitable materials, but the patentees recommend the use of zinked or galvanized iron.

SAND (Eng. and Germ.; *Sable*, Fr.); is the name given to any mineral substance in a hard granular or pulverulent form, whether strewed upon the surface of the ground, found in strata at a certain depth, forming the beds of rivers, or the shores of the sea. The siliceous sands seem to be either original crystalline formations, like the sand of Neuilly, in 6-sided prisms, terminated by two 6-sided pyramids, or the *débris* of granitic, schistose, quartzose, or other primitive crystalline rocks, and are abundantly distributed over the globe; as in the immense plains known under the names of downs, deserts, *steppes*, *landes*, &c., which, in Africa, Asia, Europe, and America, are entirely covered with loose sterile sand. Valuable metallic ores, those of gold, platinum, tin, copper, iron, titanium, often occur in the form of sand, or mixed with that earthy substance. Pure siliceous sands are very valuable for the manufacture of glass, for making mortars, filters, ameliorating dense clay soils, and many other purposes. For moulder's sand, see **FOUNDING**. Lynn and Ryegate furnish our purest siliceous sand.

SAND FOR GLASS MAKING. The Great Exhibition was well furnished with specimens of the finer kinds of sand; some of which, as those from the Isle of Wight, and the neighbourhood of Lynn, were remarkably white and beautiful. By far the finest sample of sand ever seen in this country was, however, in the American department of the Crystal Palace, and did not fail to attract the notice of those interested in such matters. This sand was contained in two or three barrels in the southern side of the building, and seems totally free from iron and every other source of contamination. It was positively as white as snow, and so far as the making of glass is concerned, may rival or supersede the best flint, even if the high price of this latter article did not form an insuperable obstacle to its employment. It was from T. Gray & Co., Boston, Massachusetts; but its geological locality was not stated. The principal exhibitors of sand for the manufacture of glass were, Sir T. Maryon Wilson, of Charlton; J. Rock, jun., of Hastings; Whittaker & Winkworth, Derbyshire; J. Claston, of Alum Bay, and J. Squire, of Yarmouth, Isle of Wight; S. Relfe, of Reigate, and G. Morrison of the same town, agent to Earl Somers; with J. Long, of Limerick; J. Deering, of Cork; T. Smedley, of Lardidno; and J. Lee, of Hartwell, near Aylesbury. These specimens of sand have all more or less of the yellow topaz hue, indicating oxide of iron, and which imparts to all glass the green tinge so very perceptible in the common window variety. To remove this oxide of iron from sand, has never yet, we believe, been attempted; though if we may judge by the trouble taken to mollify its influence in the manufacture of glass, an effectual process of the kind would be a lucrative discovery. When sand containing oxide of iron is mixed with a little charcoal and subjected at a red-heat to the action of chlorine gas, the whole of the iron is volatilized as chloride of iron, and the silica remains pure as soon as the excess of charcoal is burnt off: this experiment seems to suggest the possibility of purifying the glass makers sand, by the employment of the waste muriatic acid, now thrown away so largely by our soda makers. Even at ordinary temperatures, the solution of oxide of iron by this means might be hoped for; but there can be no practical objection to the use of a reasonable amount of heat for such a purpose, if found necessary.

SANDAL or RED SAUNDERS WOOD (*Santal*, Fr.; *Sandelholz*, Germ.); is the wood of the *Pterocarpus santalinus*, a tree which grows in Ceylon, and on the coast of Coromandel. The old wood is preferred by dyers. Its colouring matter is of a resinous nature; and is, therefore, quite soluble in alcohol, essential oils, and alkaline lyes; but sparingly in boiling water, and hardly, if at all, in cold water. The colouring matter which is obtained by evaporating the alcoholic infusion to dryness, has been called *santaline*; it is a red resin, which is fusible at 212° F. It may also be obtained by digesting the rasped sandal wood in water of ammonia, and afterwards saturating the ammonia with an acid. The *santaline* falls, and the supernatant liquor, which is yellow by transmission, appears blue by reflected light. Its spirituous solution affords a fine purple precipitate with the protochloride of tin, and a violet one with the salts of lead. Santaline is very soluble in acetic acid, and the solution forms permanent stains upon the skin.

Sandal wood is used in India, along with one-tenth of *sapan* wood (the *Cesalpinia sapan* of Japan, Java, Siam, Celebes, and the Philippine isles), principally for dyeing silk and cotton. Trommsdorf dyed wool, cotton, and linen a carmine hue by dipping them alternately in alkaline solution of the sandal wood, and in an acidulous bath. Bancroft obtained a fast and brilliant reddish-yellow, by preparing wool with an alum and tartar bath, and then passing it through a boiling bath of sandal wood and sumach,

Pelletier did not succeed in repeating this experiment. According to Toggler, wool, silk, cotton, and linen, mordanted with salt of tin, and dipped in a cold alcoholic tincture of the wood, or the same tincture mixed with 8 parts of boiling water, become of a superb ponceau-red colour. With alum, they took a scarlet-red; with sulphate of iron, a deep violet, or brown-red. Unluckily these dyes do not stand exposure to light well.

SANDARACH, is a peculiar resinous substance, the product of the *Thuya articulata*, a small tree of the coniferous family, which grows in the northern parts of Africa, especially round Mount Atlas.

The resin comes to us in pale yellow, transparent, brittle, small tears, of a spherical or cylindrical shape. It has a faint aromatic smell, does not soften, but breaks between the teeth, fuses readily with heat, and has a specific gravity of from 1.05 to 1.09. It contains three different resins; one soluble in spirit of wine, somewhat resembling picric acid (see TURPENTINE); one not soluble in that menstruum; and a third, soluble only in alcohol of 90 per cent. It is used as pounce-powder for strewing over paper erasures, as incense, and in varnishes.

SAPAN WOOD, is a species of the *Cesalpinia* genus, to which Brasil wood belongs. It is so called by the French, because it comes to them from Japan, which they corruptly pronounce Sapan. As all the species of this tree are natives of either the East Indies or the New World, one would imagine that they could not have been used as dye-stuffs in Europe before the beginning of the 16th century. Yet the author of the article "Brasil," in Rees' Cyclopaedia, and Mr. Southey, in his History of Brasil, say that *Brasil* wood is mentioned nearly one hundred years before the discoveries of Columbus and Vasco de Gama, by Chaucer, who died in 1400; that it was known many ages before his time; and that it gave the name to the country, instead of the writers giving the name to the wood, as I have stated, with Berthollet and other writers on dyeing. The *Cesalpinia sapan*, being a native of the Coromandel coast, may possibly have been transported along with other Malabar merchandises to the Mediterranean parts in the middle ages; but the importation of so lumbering an article in any considerable quantity by that channel, is so improbable, that I am disposed to believe that Brasil wood was not commonly used by the dyers of Europe before the discovery of the New World. SARD; see LAPIDARY.

SATIN (Eng., Fr., and Germ.); is the name of a silk stuff, first imported from China, which is distinguishable by its very smooth, polished, and glossy surface. It is woven upon a loom with at least five-leaved healds or heddles, and as many corresponding treadles. These are so mounted as to rise and fall four at a time, raising and depressing alternately four yarns of the warp, across the whole of which the weft is thrown by the shuttle, so as to produce a uniform smooth texture, instead of the chequered work resulting from intermediate decussations, as in common webs. See TEXTILE FABRICS. Satins are woven with the glossy or right side undermost, because the four-fifths of the warp, which are always left there during the action of the healds, serve to support the shuttle in its race. Were they woven in the reverse way, the scanty fifth part of the warp threads could either not support, or would be too much worn by the shuttle.

SATURATION, is the term at which any body has taken its full dose or chemical proportion of any other with which it can combine: as water with a salt, or an acid with an alkali in the neutro-saline state.

SAWS. Saws are formed from plates of sheet steel, and are toothed, not by hand, but by means of a press and tools. Circular saws have the advantage of being divided in their teeth very accurately by means of a division plate; this prevents irregularity of size, and imparts smoothness and uniformity of action. The larger sizes of circular saws are made in segments and connected together by means of dove-tails. All saws are hardened and tempered in oil; their irregularities are removed by hammering on blocks, and they are equalized by grinding. The several forms of teeth do not, as the casual observer may imagine, depend upon taste, but are those best fitted for cutting through the particular section, quality, or hardness of the material to be cut. The "set" of the saw consists in inclining the teeth at the particular angle known to be the best to facilitate the exit of the sawdust, and thereby allow the saw to operate more freely. Iron bars, shaftings, &c., are cut to length by a steel circular saw, in its soft state, the iron to be cut being presented to the saw red hot; the saw rotates at a prodigious rate, and is kept in cutting condition, or cool, by its lower edge being immersed in water. A bar, two inches in diameter, is cut through in a few seconds.

SCAGLIOLA, is merely ornamental plaster-work, produced by applying a pap made of finely-ground calcined gypsum, mixed with a weak solution of Flanders' glue, upon any figure formed of laths nailed together, or occasionally upon brick-work, and bestudding its surface, while soft, with splinters (*scagliole*) of spar, marble, granite, bits of concrete coloured gypsum, or veins of clay, in a semi-fluid state. The substances employed to colour the spots and patches are the several ochres, boles, *terra di Siena*, chrome yellow &c. The surface of the column is turned smooth upon a lathe, polished with stones &c.

different fineness, and finished with some plaster-pap, to give it lustre. Pillars and other flat surfaces are smoothed by a carpenter's plane, with the chisel finely serrated, and afterwards polished with plaster by friction. The glue is the cause of the gloss, but makes the surface apt to be injured by moisture, or even damp air.

SCARLET DYE. (*Teinture en écarlate*, Fr.; *Scharlachfärberei*, Germ.) Scarlet is usually given at two successive operations. The boilers (see *figs.* 469, 470, article *DYEING*.) is made of block tin, but its bottom is formed occasionally of copper.

1. *The bouillon or the colouring bath.* — For 100 pounds of cloth, put into the water, when it is little more than lukewarm, 6 pounds of argal, and stir it well. When the water becomes too hot for the hand, throw into it, with agitation, one pound of cochineal in fine powder. An instant afterwards, pour in 5 pounds of the clear mordant c, (see *TIN MORDANTS*.) stir the whole thoroughly as soon as the bath begins to boil, introduce the cloth, and wince it briskly for two or three rotations, and then more slowly. At the end of a two-hours' boil, the cloth is to be taken out, allowed to become perfectly cool, and well washed at the river, or wined in a current of pure water. (See an automatic plan of washing described under the article *RINSING MACHINE*.)

2. *The rougie, or finishing dye.* — The bouillon bath is emptied, and replaced with water, for the *rougie*. When it is on the point of boiling, 5½ pounds of cochineal in fine powder are to be thrown in, and mixed with care; when the crust, which forms upon the surface, opens of itself in several places, 14 pounds of solution of tin (as above) are to be added. Should the liquor be likely to boil over the edges of the kettle, it must be refreshed with a little cold water. When the bath has become uniform, the cloth is to be put in, taking care to wince it briskly for two or three turns; then to boil it bodily for an hour, thrusting it under the liquor with a rod whenever it rises to the surface. It is lastly taken out, aired, washed at the river, and dried.

As no person has done more for the improvement of the scarlet dyes than Poërner, I shall here give his processes in detail.

Bouillon, or colouring. — For every pound of cloth or wool, take 14 drams of cream of tartar. When the bath is boiling, and the tartar all dissolved, pour in successively 14 drams of solution of tin, (*Mordant r, Tin*.) and let the whole boil together during a few minutes. Now introduce the cloth, and boil it for 2 hours; then take it out, and let it drain and cool.

Rougie, or dye. — For every pound of woollen stuff, take 2 drams of cream of tartar. When the bath begins to boil, add 1 ounce of cochineal reduced to fine powder, stir the mixture well with a rod of willow or any white wood, and let it boil for a few minutes. Then pour in, by successive portions, 1 ounce of solution of tin (*Mordant r*), stirring continually with the rod. Lastly, dye as quickly as possible. The colour will be a beautiful scarlet.

Second scarlet process of Poërner, the *bouillon* being the same as above given, and always estimated for 1 pound of cloth or wool. *Rougie.* — Take one ounce of cochineal in fine powder, and two ounces of solution of tin without tartar.

Third scarlet process of Poërner, the *bouillon* being as above. *Rougie* for a pound of cloth. — Take two drams of cream of tartar, one ounce of cochineal, one ounce of solution of tin, and two ounces of sea salt: dye as in process 1. The salt helps the dye to penetrate into the cloth.

TABLES of the COMPOSITION of the BOUILLON and ROUGIE, by different Authors for 100 pounds of Cloth or Wool.

Composition of the Bouillon.

| Names of the Authors. | Starch. | | Cream of Tartar. | | Cochineal. | | Solution of Tin. | | Common Salt. | |
|-----------------------|---------|-----|------------------|-----|------------|-----|------------------|-----|--------------|-----|
| | lb. | oz. | lb. | oz. | lb. | dr. | lb. | oz. | lb. | oz. |
| Berthollet - - | 0 | 0 | 6 | 0 | 8 | 0 | 5 | 0 | 0 | 0 |
| Hellot - - - | 0 | 0 | 12 | 8 | 18 | 6 | 12 | 8 | 0 | 0 |
| Scheffer - - - | 9 | 0 | 9 | 6 | 12 | 4 | 9 | 6 | 0 | 0 |
| Poërner - - - | 0 | 0 | 10 | 15 | 0 | 0 | 10 | 15 | 0 | 0 |

M. Lenormand states that he has made experiments of verification upon all the formulæ of the preceding tables, and declares his conviction that the finest tint may be obtained by taking the *bouillon* of Scheffer, and the *rougie* No. 4. of Poërner. The solution which produced the most brilliant red, is that made according to the process of mordant r (*Tin*). M. Robiquet has given the following prescription for making a *printing scarlet*, for well-whitened woollen cloth.

Composition of the Rouge.

| Names of the Authors. | Starch. | | Cream of Tartar. | | Cochineal. | | Solution of Tin. | | Common Salt. | |
|-----------------------|---------|-----|------------------|-----|------------|-----|------------------|-----|--------------|-----|
| | lb. | oz. | lb. | oz. | lb. | oz. | lb. | oz. | lb. | oz. |
| Berthollet - - | 0 | 0 | 0 | 0 | 5 | 8 | 14 | 0 | 0 | 0 |
| Hellot - - | 3 | 2 | 0 | 0 | 7 | 4 | 12 | 8 | 0 | 0 |
| Scheffer - - | 3 | 2 | 3 | 2 | 5 | 7½ | 4 | 11 | 0 | 0 |
| Poërner - } | 0 | 0 | 1 | 8 | 6 | 4 | 6 | 4 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 6 | 4 | 12 | 8 | 0 | 0 |
| | 0 | 0 | 1 | 8 | 6 | 4 | 6 | 4 | 12 | 8 |

Boil a pound of pulverized cochineal in four pints of water, down to two pints, and pass the decoction through a sieve. Repeat the boiling three times upon the residuum, mix the eight pints of decoction, thicken them properly with two pounds of starch, and boil into a paste. Let it cool down to 104° F., then add four ounces of the subjoined solution of tin, and two ounces of ordinary salt of tin (muriate). When a ponceau red is wanted, two ounces of pounded curcuma (turmeric) should be added.

The solution of tin above prescribed, is made by taking one ounce of nitric acid, of specific gravity 36° B. = 1.33; one ounce of sal ammoniac; four ounces of grain tin. The tin is to be divided into eight portions, and one of them is to be put into the acid mixture every quarter of an hour.

A solution of chlorate of potassa (chloride?) is said to beautify scarlet cloth in a remarkable manner.

Bancroft proposed to supplant the nitro-muriatic acid, by a mixture of sulphuric and muriatic acids, for dissolving tin; but I do not find that he succeeded in persuading scarlet-dyers to adopt his plans. In fact the proper base is, in my opinion, a mixture of the protoxide and peroxide of tin; and this cannot be obtained by acting upon the metal with the murio-sulphuric acid. He also prescribed the extensive use of the quercitron yellow to change the natural crimson of the cochineal into scarlet, thereby economizing the quantity of this expensive dye-stuff. See *LAC DYE*.

SCHEELE'S GREEN, is a pulverulent arsenite of copper, which may be prepared as follows:—Form, first, an arsenite of potassa, by adding gradually 11 ounces of arsenious acid to 2 pounds of carbonate of potassa, dissolved in 10 pounds of boiling water; next, dissolve 2 pounds of crystallized sulphate of copper in 30 pounds of water; filter each solution, then pour the first progressively into the second, as long as it produces a rich grass-green precipitate. This being thrown upon a filter-cloth, andedulcorated with warm water, will afford 1 pound 6 ounces of this beautiful pigment. It consists of, oxide of copper 28.51, and of arsenious acid 71.46. This green is applied by an analogous double decomposition to cloth. See *CALICO-PRINTING*.

SCHWEINFURTH GREEN, is a more beautiful and velvety pigment than the preceding, which was discovered in 1814, by M.M. Russ and Sattler, at Schweinfurth, and remained for many years a profitable secret in their hands. M. Liebig having made its composition known, in 1822, it has been since prepared in a great many colour-works. Braconnot published, about the same time, another process for manufacturing the same pigment. Its preparation is very simple; but its formation is accompanied with some interesting circumstances. On mixing equal parts of acetate of copper, and arsenious acid, each in a boiling concentrated solution, a bulky olive-green precipitate is immediately produced; while much acetic acid is set free. The powder thus obtained, appears to be a compound of arsenious acid and oxide of copper, in a peculiar state; since when decomposed by sulphuric acid, no acetic odour is exhaled. Its colour is not changed by drying, by exposure to air, or by being heated in water. But, if it be boiled in the acidulous liquor from which it was precipitated, it soon changes its colour, as well as its state of aggregation, and forms a new deposit in the form of a dense granular beautiful green powder. As fine a colour is produced by ebullition during five or six minutes, as is obtained at the end of several hours by mixing the two boiling solutions, and allowing the whole to cool together. In the latter case, the precipitate, which is slight and flocky at first, becomes denser by degrees; it next betrays green spots, which progressively increases, till the mass grows altogether of a crystalline constitution, and of a still more beautiful tint than if formed by ebullition.

When cold water is added to the mixed solutions, immediately after the precipitate takes place, the development of the colour is retarded, with the effect of making it much finer. The best mode of procedure is to add to the blended solutions their own bulk of cold water, and to fill a globe up to the neck with the mixture in order to pre-

vent the formation of any such pellicle on the surface as might, by falling to the bottom, excite premature crystallization. Thus the reaction continues during two or three days with the happiest effect. The difference of tint produced by these variations arises merely from the different sizes of the crystalline particles; for when the several powders are levigated upon a porphyry slab to the same degree, they have the same shade. Schweinfurth green, according to M. Ehrmann's researches, in the *51st Bulletin de la Société Industrielle Mulhausen*, consist of, oxide of copper 31.666, arsenious acid 58.699, acetic acid 10.294. Kastner has given the following prescription for making this pigment; — For 8 parts of arsenious acid, take from 9 to 10 of verdigris; diffuse the latter through water at 120° F., and pass the pap through a sieve; then mix it with the arsenical solution, and set the mixture aside, till the reaction of the ingredients shall produce the wished-for shade of colour. If a yellowish tint be desired, more arsenic must be used. By digesting Scheele's green in acetic acid, a variety of Schweinfurth green may be obtained.

Both of the above colours are rank poisons. The first was detected a few years ago, as the colouring-matter of some Parisian *bombons*, by the *conseil de salubrité*; since which the confectioners were prohibited from using it, by the French government.

Schweinfurth Green; preparation of. 50 lbs. of sulphate of copper, and 10 lbs. of lime are dissolved in 20 gallons of good vinegar, and a boiling-hot solution of 50 lbs. white arsenic conveyed as quickly as possible into the solution; it is stirred several times, and then allowed to subside. The supernatant liquor is employed the next time for dissolving the arsenic.

The pigment is cooled on the filter, dried, pounded, sifted, and again rubbed up with a little muriatic acid.

SCOURING, or renovating articles of dress. This art has been much more studied by Frenchmen, who wear the same coats for two or three years, than by Englishmen, who generally cast them off after so many months. The workmen who remove greasy stains from dress, are called, in France, *teinturiers degraisseurs*, because they are often obliged to combine dyeing with scouring operations. The art of cleansing clothes being founded upon the knowledge of solvents, the practitioner of it should, as we shall presently illustrate by examples, be acquainted with the laws of chemical affinity.

Among the spots which alter the colours fixed upon stuffs, some are caused by a substance which may be described as *simple*, in common language; and others by a substance which results from the combination of two or more bodies, that may act separately or together upon the stuff, and which may therefore be called *compound*.

Simple stains. — Oils and fats are the substances which form the greater part of simple stains. They give a deep shade to the ground of the cloth; they continue to spread for several days; they attract the dust, and retain it so strongly, that it is not removable by the brush; and they eventually render the stain lighter coloured upon a dark ground, and of a disagreeable gray tint upon a pale or light ground.

The general principle of cleansing all spots consists in applying to them a substance which shall have a stronger affinity for the matter composing them, than this has for the cloth, and which shall render them soluble in some liquid menstruum, such as water, spirits, naphtha, oil of turpentine, &c. See BLEACHING.

Alkalis would seem to be proper in this point of view, as they are the most powerful solvents of grease; but they act too strongly upon silk and wool, as well as change too powerfully the colours of dyed stuffs, to be safely applicable in removing stains. The best substances for this purpose are — 1. Soap. 2. Chalk, fuller's earth, soap-stone or steatite (called in this country French chalk). These should be merely diffused through a little water into a thin paste, spread upon the stain, and allowed to dry. The spot requires now to be merely brushed. 3. Ox-gall and yolk of egg have the property of dissolving fatty bodies without affecting perceptibly the texture or colours of cloth, and may therefore be employed with advantage. The ox-gall should be purified, to prevent its greenish tint from degrading the brilliancy of dyed stuffs, or the purity of whites. Thus prepared (see GALL), it is the most precious of all substances known for removing these kinds of stains. 4. The volatile oil of turpentine will take out only recent stains; for which purpose it ought to be previously purified by distillation over quicklime. Wax, rosin, turpentine, pitch, and all resinous bodies in general form stains of greater or less adhesion, which may be dissolved out by pure alcohol. The juices of fruits, and the coloured juices of all vegetables in general, deposit upon clothes marks in their peculiar hues. Stains of wine, mulberries, black currants, morellos, liquors, and weld, yield only to soaping with the hand, followed by fumigation with sulphurous acid; but the latter process is inadmissible with certain coloured stuffs. Iron mould or rust stains may be taken out almost instantaneously with a strong solution of oxalic acid. If the stain is recent, cream of tartar will remove it.

Compound spots. — That mixture of rust of iron and grease called *cambois* by the

French, is an example of this kind, and requires two distinct operations; first, the removal of the grease, and then of the rust, by the means above indicated.

Mud, especially that of cities, is a compound of vegetable remains, and of ferruginous matter in a state of black oxide. Washing with pure water, followed if necessary with soaping, will take away the vegetable juices; and then the iron may be removed with cream of tartar, which itself must, however, be well washed out. Ink stains, when recent, may be taken out by washing, first with pure water, next with soapy water, and lastly with lemon juice; but if old, they must be treated with oxalic acid. Stains occasioned by smoke, or by sauces browned in a frying-pan, may be supposed to consist of a mixture of pitch, black oxide of iron, empyreumatic oil, and some saline matters dissolved in pyrolignous acid. In this case several reagents must be employed to remove the stains. Water and soap dissolve perfectly well the vegetable matters, the salts, the pyrolignous acid, and even the empyreumatic oils in a great measure; the essence of turpentine will remove the rest of the oils and all the pitchy matter; then oxalic acid may be used to discharge the iron. Coffee stains require a washing with water, with a careful soaping, at the temperature of 120° F., followed by sulphuration. The two latter processes may be repeated twice or thrice. Chocolate stains may be removed by the same means, and more easily.

As to those stains which change the colour of the stuff, they must be corrected by appropriate chemical reagents or dyes. When black or brown cloth is reddened by an acid, the stain is best counteracted by the application of water of ammonia. If delicate silk colours are injured by soapy or alkaline matters, the stains must be treated with colourless vinegar of moderate force. An earthy compound for removing grease spots is made as follows:—Take fuller's earth, free it from all gritty matter by elutriation with water; mix with half a pound of the earth so prepared, half a pound of soda, as much soap, and eight yolks of eggs well beat up with half a pound of purified ox-gall. The whole must be carefully triturated upon a porphyry slab; the soda with the soap in the same manner as colours are ground, mixing in gradually the eggs and the ox-gall previously beat together. Incorporate next the soft earth by slow degrees, till a uniform thick paste be formed, which should be made into balls or cakes of a convenient size, and laid out to dry. A little of this detergent being scraped off with a knife, made into a paste with water, and applied to the stain, will remove it. Purified ox-gall is to be diffused through its own bulk of water, applied to the spots, rubbed well into them with the hands till they disappear, after which the stuff is to be washed with soft water. It is the best substance for removing stains on woollen clothes.

The redistilled oil of turpentine may also be rubbed upon the dry clothes with a sponge or a tuft of cotton, till the spot disappear; but it must be immediately afterwards covered with some plastic clay reduced to powder. Without this precaution, a cloud would be formed round the stain, as large as the part moistened with the turpentine.

Oxalic acid may be applied in powder upon the spot previously moistened with water, well rubbed on, and then washed off with pure water.

Sulphurous acid is best generated at the moment of using it. If the clothes be much stained, they should be suspended in an ordinary fumigating chamber. For trifling stains, the sulphur may be burned under the wide end of a small card or paper funnel, whose upper orifice is applied near the cloth.

Manipulations of the scower.—These consist, first, in washing the clothes in clear soft water, or in soap-water. The cloth must be next stretched on a sloping board, and rubbed with the appropriate reagent as above described, either by a sponge or a small hard brush. The application of a redhot iron a little way above a moistened spot often volatilizes the greasy matter out of it. Stains of pitch, varnish, or oil paint, which have become dry, must first be softened with a little fresh butter or lard, and then treated with the powder of the scouring ball. When the gloss has been taken from silk, it may be restored by applying the filtered muceilage of gum tragacanth; stretching it upon a frame to dry. Ribbons are glossed with isinglass. Lemon juice is used to brighten scarlet spots, after they have been cleaned.

SCREW MAKING. *Henn & Bradley, Chespside, Birmingham—Manufacturers.* Taper wood screws in iron, brass, and copper; iron thread screws for machinery of every description, and for stoves, grates, &c.

Taper hand-rail screws adapted for pianoforte-makers and fine cabinet work.

Operation 1. From a coil of wire placed on a wheel, and introduced into the screw-making machine, a piece sufficient to form a screw is cut off, caught up and heated, that is to say, the portion which forms the head is compressed into shape and the now called "blank" is dropped into a receptacle below. Operation 2. consists in flattening the head and smoothing the counter-sink which is performed by the "blank" being held in both clams, and having a cutter revolving in front, and another behind. 3. Slitting; the "blank" is placed in a pair of nippers, which is movable on centres by means of a lever action; the head is pressed against a small revolving circular saw, and the slit made.

4. Threading is effected by the "blank" being introduced into a pair of clams which is attached to a spindle, the back part of which is cut with a worm or thread corresponding to that of the screw to be cut, and which propels forward the clams and the "blank" against small toothed cutters, which groove out the thread; three runnings down are sufficient to complete the manufacture of an ordinary sized screw. The difference in the fineness of the threads arises from the shape of the cutters.

SEAL ENGRAVING. The art of engraving gems is one of extreme nicety. The stone having received its desired form from the lapidary, the engraver fixes it by cement to the end of a wooden handle, and then draws the outline of his subject, with a brass needle or a diamond, upon its smooth surface.

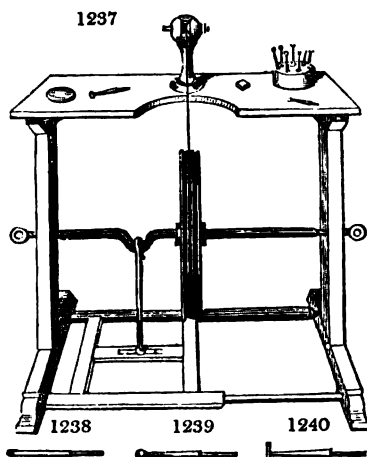


Fig. 1237. represents the whole of the seal engraver's lathe. It consists of a table on which is fixed the mill, a small horizontal cylinder of steel, into one of whose extremities the tool is inserted, and which is made to revolve by the usual fly-wheel, driven by a treddle. The tools that may be fitted to the mill-cylinder, are the following: fig. 1238. a hollow cylinder, for describing circles, and for boring; fig. 1239. a knobbed tool, or rod terminated by a small ball; fig. 1240. a stem terminated with a cutting disc, whose edge may be either rounded, square, or sharp; being in the last case called a saw.

Having fixed the tool best adapted to his style of work in the mill, the artist applies to its cutting point, or edge, some diamond powder, mixed up with olive oil; and turning the wheel, he holds the stone against the tool, so as to produce the wished-for delineation and erosion. A similar apparatus is used for engraving on glass.

In order to give the highest degree of polish to the engraving, tools of boxwood, pewter, or copper, bedaubed with moistened tripoli or rotten-stone, and lastly, a brush, are fastened to the mill. These are worked like the above steel instruments. Modern engravings on precious stones, have not in general the same fine polish as the antique. The article *Gems*, in *Rees' Cyclopaedia*, contains a variety of valuable information on this subject, equally interesting to the artist and the scholar.

SEAL FISHERY. The seal fishery of Newfoundland has now become the most important part of the trade of that colony. Although not so extensive a staple, or so generally followed as the cod fishery, yet when the capital and time employed, and the almost certain and immediate return for investment, are taken into consideration, it is by far the most profitable part of the business of that colony, or perhaps of any other part of the British empire.

A quarter of a century ago, there were only about 50 vessels, varying from 30 to 60 tons burthen, engaged in this branch of trade; but within that period it has been gradually increasing. In the year 1850, the outfit for this fishery from Newfoundland consisted of 229 vessels, of 20,581 tons, employing 7,919 men. The number of seals taken was 440,828. According to the custom-house returns for that year, the total value of skins and oil produced from the sale amounted to 298,796*l*. In the present year, 1852, the outfit consisted of 367 vessels, of 35,760 tons, employing about 13,000 men. The returns and value of this year's fishery have not yet been ascertained. Although it was a disastrous season, in respect to loss of vessels, yet the catch of seals upon the whole was above an average one, there being from half to three quarters of a million seals captured.

The vessels engaged in this business are from 75 to 200 tons burthen. Those lately added to the sailing fleet, and which are now considered of the most suitable sizes, range from 130 to 160 tons. Vessels of this size carry from 40 to 50 men. The season of embarking for the voyage is from the 1st to the 15th of March. The voyage seldom exceeds two months, and is often performed in two or three weeks. Several vessels make two voyages in the season, and some perform the third voyage within the space of two months and a half.

The seals frequenting the coast of Newfoundland are supposed to whelp their young in the months of January and February; this they do upon pans and fields of ice, on the coast, and to the northward of Labrador. This ice, or the whelping ice, as it is termed, from the currents and prevailing northerly and north-east winds, trends towards

the east and north-east coast of Newfoundland, and is always to be found on some part of the coast after the middle of March, before which time the young seals are too young to be profitable. The young seal does not take to the water until it is three months old. They are often discovered in such numbers within a day's sail of the port, that three or four days will suffice to load a vessel with the pelts, which consist of the skin and fat attached, this being taken off while the animal is warm; the carcase, being of no value, is left on the ice. The young seals are accompanied by the old ones, which take to the water on the approach of danger. When the ice is jammed, and there is no open water, large numbers of the old seals are shot. The young seals are easily captured; they offer no resistance, and a slight stroke of a bat on the head readily dispatches them. When the pelts are taken on board, sufficient time is allowed for them to cool on deck. They are then stowed away in bulk in the hold, and in this state they reach the market, at St. John's and other ports in the island. Five-sevenths of the whole catch reach the St. John's market. A thousand seals are considered as a remunerating number; but the majority of the vessels return with upwards of 3,000, many with 5,000 and 6,000, and some with as many as 7,000, 8,000, and 9,000. Seals were formerly sold by tale; they are now all sold by weight,—that is, so much per cwt. for fat and skin.

The principal species captured are the hood and harp seal. The bulk of the catch consists of the young hood and harp in nearly equal proportions. The best and most productive seal taken is the young harp. There are generally four different qualities in a cargo of seals, namely,—the young harp, young hood, old harp and bedlamer (the latter is the year old hood), and the old hood. There is a difference of 2s. per cwt. in the value of each denomination.

The first operation after landing and weighing is the skinning, or separating the fat from the skin; this is speedily done, for an expert skinner will skin from 300 to 400 young pelts in a day. After being dry-salted in bulk for about a month, the skins are sufficiently cured for shipment, the chief market for them being Great Britain. The fat is then cut up and put into the seal-vats.

The seal-vat consists of what are termed the crib and pan. The crib is a strong wooden erection, from 20 to 30 feet square, and 20 to 25 feet in height. It is firmly secured with iron clamps, and the interstices between the upright posts are filled in with small round poles. It has a strong timber floor, capable of sustaining 300 or 400 tons. The crib stands in a strong wooden pan, 3 or 4 feet larger than the square of the crib, so as to catch all the drippings. The pan is about 3 feet deep, and tightly caulked. A small quantity of water is kept on the bottom of the pan, for the double purpose of saving the oil in case of a leak, and for purifying it from the blood and any other animal matter of superior gravity. The oil made by this process is all cold-drawn; no artificial heat is applied in any way, which accounts for the unpleasant smell of seal oil. When the vats begin to run, the oil drops from the crib upon the water in the pan; and as it accumulates it is casked off, and ready for shipment. The first running, which is caused by compression from its own weight, begins about the 10th of May, and will continue to yield what is termed *pale seal oil* from two to three months, until from 50 to 70 per cent. of the quantity is drawn off, according to the season, or in proportion to the quantity of old seal fat being put into the vats. From being tougher, this is not acted upon by compression, nor does it yield its oil until decomposition takes place; and hence it does not, by this process, produce pale seal oil. The first drawings from the vats is much freer from smell than the latter. As decomposition takes place, the colour changes to straw, becoming every day, as the season advances, darker and darker, and stinking worse and worse, until it finally runs brown oil. As this running slackens, it then becomes necessary to turn over what remains in the vat. The crib being generally divided into nine apartments or pounds, this operation is performed by first emptying one of the pounds, and dispersing the contents over the others, and then filling and emptying them alternately until the entire residue, by this time a complete mass of putrefaction, is turned over. By this process a further running of brown oil is obtained. The remains are then finally boiled out in large iron pots, which, during the whole season, are kept in pretty constant requisition for boiling out the cuttings and clippings of the skinning and other parts of the pelts, which it is not found advisable to put into the vats. The produce of this, and the remains of the vats, are what is termed the boiled seal oil. These operations occupy about six months, and terminate towards the end of September.

During the months of July, August, and September, the smell and effluvia from the vats and boiling operation are almost insufferable. The healthy situation of St. John's, from its proximity to the sea, and the high and frequent local winds, is doubtless the cause of preventing much sickness at this season of the year. I have never known any disease or epidemic attributable to such a cause. The men more immediately employed about the seal-vats have a healthy and vigorous appearance.

Some improvement has taken place since the great fire of 1846, when all the seal-vats

in the town were destroyed. Many of the manufacturers have erected their new vats on the south or opposite side of the harbour; but there still remains sufficient vestiges of the seal trade to cause a summer residence in the town of St. John's anything but desirable. Even the country for several miles around St. John's affords no protection from these horrible stenches. The animal remains from the vats, and the offal from the cod-fish, are found to be such a valuable manure, that they are readily purchased by the farmers in the neighbourhood; and from whatever quarter the wind blows, the pedestrian in his rural walk has little chance of breathing a genial atmosphere.

After a year's residence in Newfoundland, the attention of the author was turned to some mode of improving the manufacture of the seal oil. The result of several experiments upon the different qualities of seal's fat satisfied him that the whole produce of the fishery, if taken while the material is fresh, as it generally arrives in the market, and subjected to a process of artificial heat, was capable of yielding, not only a uniform quality of oil, but the oil so produced was much better in quality than the best prepared by the old process, and free from the unpleasant smell common to all seal oil. His subsequent experiments resulted in the invention of a steam apparatus for rendering seal and other oils, which has been found to answer an admirable purpose, and for which he has received letters-patent under the Great Seal of the Island of Newfoundland, securing to him the right of his invention for fourteen years.

The advantage of this process must be manifest, when it is understood that twelve hours suffice to render the oil, which by the old process requires about six months; that a uniform quality of oil is produced superior to the best *pale* by the old process, and free from smell; that a considerable per-centage is saved in the yield, and what is termed *pale seal*, produced from the old as well as from the young seal. (The sample herewith sent Dr. Ure is from the old hood seal.) Besides, if this process were universally adopted, the manufacturing season would cease by the 31st of May, and the community would be saved from the annoyance attending the old process.

The chief market for seal oil and skins has hitherto been Great Britain and Ireland; a few cargoes occasionally go to the continental cities. This year, for the first time, a new market for seal oil has been opened in the United States, owing to the greatly increased consumption of oil in that country, together with the failure of their whale fishery. Upwards of 2000 tons of this year's produce have already been shipped to that country. The latter shipments, however, have not realised to the shippers the prices of the first, from the fact that, upon the trial of this oil, although it was found to be valuable for its combustible qualities, yet in a hot climate it was altogether unfit for domestic purposes, on account of its singularly offensive smell.

In the United States the great consumption of oil is for domestic purposes; the chief cities only as yet being lighted with gas, and that but partially, from their constant increase. Candles, unless of the most expensive kind, will not suit that climate, particularly in the summer season; and hence oil and camphine, where gas is not used, are the chief ingredients for lamps. All animal oils used in that country, whether of sperm, right whales, or lard, are rendered by artificial heat, and in consequence free from the unpleasant smell of our cold-drawn seal oil.

From his having exhibited samples of his oil in America, the subscriber has fully ascertained that, on account of its yielding so brilliant a light, and producing no offensive smell, it will command a much higher price than the best *pale*, prepared by the cold-drawn process.—*S. G. Archibald, St. John's, Newfoundland.*

SEALING-WAX.—(*Cire à cacheter*, Fr.; *Stegellack*, Germ.) The Hindus from time immemorial have possessed the resin lac, and were long accustomed to use it for sealing manuscripts before it was known in Europe. It was first imported from the East into Venice, and then into Spain; in which country sealing-wax became the object of a considerable commerce, under the name of Spanish-wax.

If shell-lac be compounded into sealing-wax, immediately after it has been separated by fusion from the palest qualities of stick or seed lac, it then forms a better and less brittle article, than when the shellac is fused a second time. Hence sealing-wax, rightly prepared in the East Indies, deserves a preference over what can be made in other countries, where the lac is not indigenous. Shellac can be restored in some degree, however, to a plastic and tenacious state by melting it with a very small portion of turpentine. The palest shellac is to be selected for bright-coloured sealing-wax, the dark kind being reserved for black.

The following prescription may be followed for making red sealing-wax:—Take 4 ounces of shell-lac, 1 ounce of Venice turpentine (some say $1\frac{1}{2}$ ounces), and 3 ounces of vermilion. Melt the lac in a copper pan suspended over a clear charcoal fire, then pour the turpentine slowly into it, and soon afterwards add the vermilion, stirring briskly all the time of the mixture with a rod in either hand. In forming the round sticks of sealing-wax, a certain portion of the mass should be weighed while it is ductile, divided into the desired number of pieces, and then rolled out upon a warm marble

slab, by means of a smooth wooden block, like that used by apothecaries for rolling a mass of pills. The oval sticks of sealing-wax are cast in moulds, with the above compound in a state of fusion. The marks of the lines of junction of the mould-box may be afterwards removed by holding the sticks over a clear fire, or passing them over a blue gas-flame. Marbled sealing-wax is made by mixing two, three, or more coloured kinds of it, while they are in a semi-fluid state. From the viscosity of the several masses, their incorporation is left incomplete, so as to produce the appearance of marbling. Gold sealing-wax is made simply by stirring gold-coloured mica spangles into the melted resins. Wax may be scented by introducing a little essential oil, essence of musk, or other perfume. If 1 part of balsam of Peru be melted along with 99 parts of the sealing-wax composition, an agreeable fragrance will be exhaled in the act of sealing with it. Either lamp black or ivory black serves for the colouring-matter of black wax. Sealing-wax is often adulterated with rosin; in which case it runs into thin drops at the flame of a candle.

The following prescriptions are good:—

Red No. 1.—4 oz. Venetian turpentine, 6 ozs. shell-lac, $\frac{3}{4}$ ozs. colophony, $\frac{1}{2}$ oz. cinnabar &c.

Red No. 2.—Turpentine and shell-lac like No. 1., colophony and cinnabar each $\frac{1}{2}$ oz., magnesia &c.

Red No. 3.—4 ozs. turpentine, $5\frac{1}{2}$ ozs. shell-lac, $\frac{1}{2}$ oz. colophony, $\frac{1}{2}$ oz. cinnabar, magnesia, &c.

Fine Black— $4\frac{1}{2}$ ozs. Venetian turpentine, 9 ozs. shell-lac, $\frac{1}{2}$ oz. colophony, lamp-black mixed with oil of turpentine as much as is required.

Black—4 ozs. Venetian turpentine, 8 ozs. shell-lac, 3 ozs. colophony, lamp-black, and oil of turpentine.

Yellow—2 ozs. Venetian turpentine, 4 ozs. shell-lac, $\frac{1}{2}$ oz. colophony, $\frac{3}{4}$ oz. king's yellow, $\frac{1}{2}$ dram magnesia and oil of turpentine.

Dark Brown—4 ozs. Venetian turpentine, $7\frac{1}{2}$ ozs. shell-lac, $\frac{1}{2}$ oz. brown English earth (ochre), magnesia as above.

Brown—4 ozs. Venetian turpentine, 7 ozs. shell-lac, 3 ozs. colophony, $\frac{1}{2}$ oz. English earth (ochre), magnesia as above.

Light Brown—4 ozs. Venetian turpentine, $7\frac{1}{2}$ ozs. shell-lac, 1 oz. brown earth, $\frac{1}{2}$ oz. cinnabar, $\frac{1}{2}$ oz. prepared chalk, magnesia as above.

Light Brown—4 ozs. Venetian turpentine, 7 ozs. fine shell-lac, 3 ozs. colophony, $\frac{1}{2}$ oz. English earth, $\frac{1}{2}$ oz. cinnabar, 1 oz. washed chalk, magnesia as above.

Dark Blue—3 ozs. Venetian turpentine, 7 ozs. fine shell-lac, 1 oz. colophony, 1 oz. mineral blue, magnesia as above.

Green—2 ozs. Venetian turpentine, 4 ozs. shell-lac, $\frac{1}{2}$ oz. colophony, $\frac{1}{2}$ oz. king's yellow, $\frac{1}{2}$ oz. mountain blue, magnesia as above.

Carmine Red—2 ozs. Venetian turpentine, 4 ozs. shell-lac, 1 oz. colophony, $\frac{1}{2}$ oz. Chinese red, 1 dram magnesia, with oil of turpentine.

Gold—4 ozs. Venetian turpentine, 8 ozs. shell-lac, 14 sheets of genuine leaf gold, $\frac{1}{2}$ oz. bronze, $\frac{1}{2}$ oz. magnesia with oil of turpentine.

SEA-WATER, is composed as follows, according to the author of the article *Salines*, in the *Dictionnaire Technologique*:—Chloride of sodium, 2.50; chloride of magnesium, 0.35; sulphate of magnesia, 0.58; carbonates of lime and magnesia, 0.02; sulphate of lime, 0.01; water, 96.54, in 100 parts. See SALT, SEA.

Sea-water, distillation of. Three of Her Majesty's ships, the *Arrogant*, 46, Captain Fitzroy, the *Plumper*, 11, Commander Nolloth, and the *Reynard*, 11, Commander Crawcroft, have been furnished with the Government distilling and cooking galley, constructed by Mr. Grant: other galleys of the same kind are also in course of manufacture for the largest class of vessels. The *Dauntless*, 1,496 tons, the *Termagant*, 1,556 tons, and the *Encounter*, 906 tons, all new ships on the screw principle, are ordered to have first class machines of the above description. By the improvements made since the introduction of the galleys into the naval service, the quantity of fresh water obtained by the distillation of salt water, during the period it is required to keep the fires alight in the galley for the purposes of cooking, will, on the average, supply each individual on board the vessels with one gallon of distilled water every day! The latter kind of water continues to be preferred for drinking and culinary purposes to the water usually supplied to the ships: it passes immediately from the condenser into the water tanks at the same temperature as the surrounding ocean. In these tanks it becomes perfectly aerated, losing altogether the vapid flavour common to all distilled water in the course of a few hours, without the aid of chemical preparation or mechanical arrangement, by the simple fact of the action imparted to the fluid by the motion of the ship when at sea. A series of very interesting and important experiments have, however, been made, and are still in progress, on board the *Illustrious*, 72, Captain Yates; bearing the flag of Rear Admiral Presert, C. B. in the harbour, by

Mr. Cross, with the view of imparting at the moment of distillation the oxygen of which the water is deprived in the process, and giving to it that briskness which is found in spring water. This is effected by passing a proportionate current of electricity through the particles of water by means of an extremely simple and self-acting apparatus. The results of the experiments made have been highly satisfactory. The only point to be determined is, whether any artificial means, either chemical or mechanical, are required for aerated distilled water on board ship, as it is found that such water becomes sufficiently aerated in a few hours by the motion imparted to it by the ship; but if the water is required for immediate use, Mr. Cross's application produces the object desired most effectually.

SEGGAR, or SAGGER, is the cylindric or oval case of fire-clay, in which fine stoneware is enclosed while being baked in the kiln.

SELENIUM, from Σελήνη, the moon, is a metalloïd principle, discovered by Berzelius, in 1817. It occurs sparingly in combination with several metals, as lead, cobalt, copper, and quicksilver, in the Harz, at Tilkerode; with copper and silver (*Eukairite*) in Sweden, with tellurium and bismuth in Norway, with tellurium and gold in Siebenbürgen, in several copper and iron pyrites, and with sulphur in the volcanic products of the Lipari Islands. Selenium has been found likewise in a red sediment which forms upon the bottoms of the lead chambers in which oil of vitriol has been made from a peculiar pyrites, or pyritous sulphur. The extraction of selenium from that deposit is a very complex process.

Selenium, after being fused and slowly cooled, appears of a bluish-gray colour, with a glistening surface; but it is reddish brown, and of metallic lustre when quickly cooled. It is brittle, not very hard, and has little tendency to assume the crystalline state. Selenium is dark-red in powder, and transparent, with a ruby cast, in thin scales. Its specific gravity is 4.30. It softens at the temperature of 176° F., is of a pasty consistence at 212°, becomes liquid at a somewhat higher heat, forming in close vessels dark-yellow vapours, which condense into black drops; but in the air, the fumes have a cinabar-red colour.

This singular substance, apparently intermediate in its constitution between sulphur and metals, has not hitherto been applied to any use in the arts.

SELF-ACTING MACHINES. See MACHINES.

SELTZER WATER. See SODA-WATER, and WATERS, MINERAL.

SEMOULE. The name given in France, and used in this country, to denote the large hard grains of wheat flour retained in the bolting machine after the fine flour has been passed through its meshes. The best *sémoule* is obtained from the wheat of the southern parts of Europe. With the *sémoule*, the fine white Parisian bread called *gruau* is baked. Skillful millers contrive to produce a great proportion of *sémoule* from the large-grained wheat of Naples and Odessa.

SEPIA, is a pigment prepared from a black juice secreted by certain glands of the cuttle-fish, which the animal ejects to darken the water when it is pursued. One part of it is capable of making 1000 parts of water nearly opaque. All the varieties of this mollusca secrete the same juice; but the *Sepia officinalis*, the *Sepia idollo*, and the *Sepia tunicata*, are chiefly sought after for making the pigment. The first, which occurs abundantly in the Mediterranean, affords most colour; the sac containing it being extracted, the juice is to be dried as quickly as possible, because it runs rapidly into putrefaction. Though insoluble in water, it is extremely diffusible through it, and is very slowly deposited. Caustic alkalis dissolve the sepia, and turn it brown; but in proportion as the alkali becomes carbonated by exposure to air, the sepia falls to the bottom of the vessel. Chlorine bleaches it slowly. It consists of carbon in an extremely divided state, along with albumine, gelatine, and phosphate of lime.

The dried native sepia is prepared for the painter, by first triturating it with a little caustic lye, then adding more lye, boiling the liquid for half an hour, filtering, next saturating the alkali with an acid, separating the precipitate, washing it with water, and finally drying it with a gentle heat. The pigment is of a brown colour, and a fine grain.

SEPTARIA, called antiently *ludus Helmontii* (the *quoits* of Van Helmont, from their form), are lenticular concretions of clay ironstone, intersected by veins of calc-spar, which, when calcined, and ground to powder, form an excellent hydraulic cement. See MORTAR, HYDRAULIC.

SERPENTINE, is a mineral of the magnesian family, of a green colour; it is scratched by calcareous spar, is sectile, tough, and therefore easily cut into ornamental forms. It occurs in Unst and Fetlar, in Shetland; at Portsoy, in Banffshire; in Cornwall; and the isle of Holyhead. The floors of bakers' ovens are advantageously laid with slabs of serpentine.

SEWING BY MACHINERY. The Wilson machine is in our opinion a great triumph of American genius; it is no larger than a neat small work-box, very portable

and convenient, and we have seen fine shirt bosoms and collars stitched by it in a more perfect and accurate manner than any we have ever seen done by hand work. When we first noticed How's Sewing-machinery, in 1847, there was not a solitary machine of the kind in active operation, in our whole country, if in the world. There are now, we believe, about 500 in operation, and we have been told by Mr. Wilson that the orders for his machines cannot be supplied fast enough. There are at present a hundred machines about finished at the Company's works — Wheeler, Wilson, and Co, Water-town, Connecticut, and these are all engaged.

When we look at the progress made in sewing machines, we expect them to create a social revolution, for a good housewife will sew a fine shirt, doing all the seams in fine stitching, by one of Wilson's little machines in a single hour. The time thus saved to wives, tailors, and sempstresses of every description, is of incalculable importance, for it will allow them to devote their attention to other things, during the time which used to be taken up with dull seam-sewing. Young ladies will have more time to devote to ornamental work, (it would be better for them all if they did more of it), and families in which there are a number of children, which require a continual stitching in making and mending from morning till night, will yet be blessed by the improved sewing-machine.

SHAFT, in mining, signifies a perpendicular or slightly inclined pit.

SHAGREEN. (*Chagrin*, Fr. and Germ.) The true oriental shagreen is essentially different from all modifications of leather and parchment. It approaches the latter somewhat, indeed, in its nature, since it consists of a dried skin, not combined with any tanning or foreign matter whatever. Its distinguishing characteristic is having the grain or hair side covered over with small rough round specks or granulations.

It is prepared from the skins of horses, wild asses, and camels; of strips cut along the chine, from the neck towards the tail, apparently because this stronger and thicker portion of the skin is best adapted to the operations about to be described. These fillets are to be steeped in water till the epidermis becomes loose, and the hairs easily come away by the roots; after which they are to be stretched upon a board, and dressed with the currier's fleshing-knife. They must be kept continually moist, and extended by cords attached to their edges, with the flesh side uppermost upon the board. Each strip now resembles a wet bladder, and is to be stretched in an open square wooden frame by means of strings tied to its edges, till it be as smooth and tense as a drum-head. For this purpose it must be moistened and extended from time to time in the frame.

The grain or hair side of the moist strip of skin must next be sprinkled over with a kind of seeds called *Allabuta*, which are to be forced into its surface either by tramping with the feet, or with a simple press, a piece of felt or other thick stuff being laid upon the seeds. The seeds belong probably to the *Chenopodium album*. They are lenticular, hard, of a shining black colour, farinaceous within, about the size of poppy seed, and are sometimes used to represent the eyes in wax figures.

The skin is exposed to dry in the shade, with the seeds indented into its surface; after which it is freed from them by shaking it, and beating upon its other side with a stick. The outside will be then horny, and pitted with small hollows corresponding to the shape and number of the seeds.

In order to make the next process intelligible, we must advert to another analogous and well-known operation. When we make impressions in fine-grained dry wood with steel punches or letters of any kind, then plane away the wood till we come to the level of the bottom of these impressions, afterwards steep the wood in water, the condensed or punched points will swell above the surface, and place the letters in relief. Snuff-boxes have been sometimes marked with prominent figures in this way. Now shagreen is treated in a similar manner.

The strip of skin is stretched in an inclined plane, with its upper edge attached to hooks and its under one loaded with weights, in which position it is thinned off with a proper semi-lunar knife, but not so much as to touch the bottom of the seed-pits or depressions. By maceration in water, the skin is then made to swell, and the pits become prominent over the surface which had been shaved. The swelling is completed by steeping the strips in a warm solution of soda, after which they are cleansed by the action of salt brine, and then dyed.

In the East the following processes are pursued. Entirely white shagreen is obtained by imbuing the skin with a solution of alum, covering it with the dough made with Turkey wheat, and after a time washing this away with a solution of alum. The strips are now rubbed with grease or suet, to diminish their rigidity, then worked carefully in hot water, curried with a blunt knife, and afterwards dried. They are dyed red with decoction of cochineal or kermes, and green with fine copper filings and sal ammoniac, the solution of this salt being first applied, then the filings being strewn upon the skin, which must be rolled up and loaded with weights for some time; blue is given with indigo, quicklime, soda, and honey; and black, with galls and coppers.

SHALE, or SLATE-CLAY, is an important stratiform member of the coal-measures. See **PRICOAL.**

SHAMOY LEATHER. See **LEATHER.**

SHAWL MANUFACTURE. Shawls were originally woven in the heart of India, from the fine silky wool of the Thibet goat; and the most precious of them still come from Cashmere. The wool of which these articles are manufactured consists of two distinct sorts, called wool and kemp. The wool is beautifully rich and soft to the touch, and is probably superior in this respect to the finest continental lamb's wool, and equal in richness to the Thibet wool. It is also divisible into qualities. The kemp presents the appearance of a coarse rough hair, such as is avoided by the manufacturer in all purchases of wools, deteriorating as it does the appearance of even common fabrics by its inferiority and harshness.

The two wools as shorn from the goat are closely intermingled, and present the appearance of a coarse hairy wool of a very low character, but a minute inspection shows that part of it is of a very fine quality. In order to separate this fine quality from the coarse, it is necessary to do so fibre by fibre, and this has to be effected entirely by hand, no machinery having as yet been applied to this purpose. The process is both difficult and tedious, one person not being able to separate more than half an ounce in twelve hours.

After the separation of the qualities it is desirable further to divide it, in order to make a warp yarn for fabrics like the shawls; but this was impossible in the present instance, owing to the small quantity produced, otherwise the fabric would have been much finer. In the dresses this result has been achieved, because the warp is of silk, and the quantity required for the weft was therefore not so great in proportion.

The specimen of coarse cloth in the Great Exhibition was entirely manufactured of coarse hairs or kemp after it was assorted from the finer material of the wool. In a general way this is considered worthless.

SHEATHING OF SHIPS. For this purpose many different metals and metallic alloys have been lately proposed. From a train of researches which I made for an eminent copper company, a few years ago, upon various specimens of sheathing which had been exposed upon ships during many voyages, it appeared that copper containing a minute, but definite, proportion of tin, was by far the most durable.

The process of coppering vessels, which has of late years been generally adopted, in order to protect their bottoms from the injurious effects of insects in hot countries, and prevent the adherence of barnacles, &c., which greatly impede the progress of the vessels, had been open to many objections; for not only was the prime cost of the material very great, but the expense of rolling it into sheets, and the frequent renewal of parts which had been injured during the voyage, made this copper covering a serious item in the expenses attendant upon fitting out ships.

In order to make this application of copper still more general, Sir Humphry Davy turned his attention to the subject, and endeavoured to devise some method of counteracting the rapid oxidation which took place on its exposure to the sea water, as it was rare for the copper bottom of a ship to last longer than five or six years. It struck Sir H. Davy that if a portion of zinc were applied to the copper it would counteract the process of oxidation; and a vessel sheathed with copper and zinc plates was accordingly sent a voyage to a distant part of the world, from whence it returned perfectly uninjured by the salt water, as far as the metal was concerned, but in as foul a state as if there had been no sheathing upon the bottom of the vessel. The presence of the zinc had prevented the oxidation of the copper, but had stopped that electric action which was necessary to resist the marine deposit. The problem, therefore, still remained to be solved, whether any metallic composition could be found for the sheathing of ships capable of preventing the bottom from fouling, and at the same time resisting the process of oxidation. To the solution of this problem Mr. Muntz, who is a metal-roller at Birmingham, directed his attention, and commenced a series of experiments, which resulted in his taking out a patent in 1832. This invention slowly, but steadily, attracted the notice of the shipping interest of the country, and it appeared that in 1834 in the port of London 20 ships were sheathed with metal prepared by Muntz's patent process. The number gradually increased, until, in 1843, there were in the same port 257 vessels sheathed with the new composition, of which 17,947 cwt. were sold in the last mentioned year. The improved metal-sheathing was a mixture of copper and zinc, which was cheaper than copper, more easily worked, and lasted longer than the pure metal before in use. In the specification of Mr. Muntz's patent, the nature of his invention is thus described:—"I take that quality of copper known to the trade by the appellation of 'best selected copper,' and that quality of zinc known in England as 'foreign zinc,' and melt them together in the usual manner, in any proportions between 50 per cent. of copper to 50 per cent. of zinc, and 63 per cent. of copper to 37 per cent. of zinc, both of which extremes, and all intermediate proportions, will roll at a red heat; but, as

too large a proportion of copper increases the difficulty of working the metal, and too large a proportion of zinc renders the metal too hard when cold, and not sufficiently liable to oxidation, I prefer the alloy to consist of about 60 per cent. of copper to 40 per cent. of zinc." It was proved on the part of Mr Muntz, that any person acquainted with the trade of a metal roller could manufacture this composition from the description of the invention contained in the specification; and it appeared, that between February and April, 1843, another party had made a quantity of sheathing, amounting in value to about 700*l.* or 800*l.*, some of which was sold by them in Liverpool; and which, on being analysed, was found to be composed of the same proportions of copper and zinc as those pointed out in the above specification as the best alloy for the purpose, viz. 60 per cent. of copper and 40 per cent. of zinc.

For the defence it was pleaded, that there had been no infringement of the patent; that the invention was not new, and that Mr. Muntz was not the first and true inventor; and also that the specification was had for uncertainty, &c. Upon the first point—the infringement—the evidence seemed very clear; but the main ground of defence was, that in 1800, a Mr. Collins obtained a patent for a composition for sheathing ships, which, it was argued, was substantially the same invention as that which the plaintiff claimed as his own. The specification of Collins's patent said, "the yellow sheathing (the sheathing in question) consists chiefly of zinc and copper. The compound must be heated, and in that state rolled; 100 parts of copper and 80 of zinc afford a good composition; but the proportions may be varied, or other metallic substances added, provided the property of bearing the mechanical process, when added, is not destroyed." Evidence was given on the part of the defendants to show that some of the metallic sheathing manufactured by them after April, 1843, was made from the specification in Collins's patent alone, and several witnesses were also called to prove, on their behalf, that a composition of copper and zinc, in the proportion of 60 per cent. of the former to 40 per cent. of the latter, had been made in the years 1828 and 1829; but it did not appear that any plates of this composition had ever been applied to the sheathing of ships. The defendants also raised various objections to the plaintiff's specification.

The Lord Chief Justice, before proceeding to charge the jury, told them that if they were desirous of hearing the whole of the evidence read over, he should wish to take another day for that purpose; but if, having heard the evidence, they did not require that assistance, he would at once proceed to call their attention to the points on which they would have to give their verdict. The jury immediately said, that it would be unnecessary for his Lordship to read the evidence.

The Lord Chief Justice then left it to them to say, in the first place, whether there had been any infringement of the patent granted to the plaintiff, assuming the patent to be good; secondly, if so, whether the manufacture was a new invention, or whether it had been already made public by Collins's patent; and, thirdly, whether the specification of the plaintiff's patent was sufficiently plain and intelligible to enable other persons to make the composition for which the patent had been granted. His Lordship also gave it as his opinion, upon the matter of law arising in the case, that the nature of the plaintiff's invention was well described by the title of the patent,—“An improved manufacture of metal plates for sheathing the bottoms of ships or other such vessels;” that neither “best selected copper” nor “foreign zinc” formed part of the invention, which consisted in the discovery of a composition for sheathing by which a proper degree of oxidation was obtained, and no more; that rolling the metal at a red heat was not claimed as part of the invention, and that the invention did not particularize any proportions but those of 60 per cent. of copper and 40 per cent. of zinc, as applicable for the purpose of making his metallic sheathing, although he had designated other proportions between the extremes of which the metal would melt at a red heat.—*Newton's Journal*, xxiv. 300.

SHELLAC. See LAC, and SEALING-WAX.

SHOE-BLACKING.

| | | | | | |
|----------------|---|---|---|---|--------------------|
| Ivory black | - | - | - | - | 8 oz. |
| Treacle | - | - | - | - | 6 oz. |
| Vinegar | - | - | - | - | 24 oz. |
| Oil of vitriol | - | - | - | - | 1 oz. (by weight.) |
| Sperm oil | - | - | - | - | 10 dr. |

To be mixed in the above order in a mortar.

Blacking (paste).

| | | | | | |
|------------------|---|---|---|---|-------------------|
| Ivory black | - | - | - | - | 2 lbs. |
| Oil of vitriol | - | - | - | - | 4 oz. |
| Treacle | - | - | - | - | 1 lb. |
| Sweet oil | - | - | - | - | 4 oz. |
| Vinegar | - | - | - | - | 5 oz. |
| Sulphate of iron | - | - | - | - | $\frac{1}{2}$ oz. |

(Dissolved in hot water 5 oz.)

| | | | | | |
|------------|---|---|---|---|------------------------|
| Gum arabic | - | - | - | - | $\frac{1}{2}$ oz. Mix. |
|------------|---|---|---|---|------------------------|

SIENTITE, is a granular aggregated compound rock, consisting of felspar and hornblende, sometimes mixed with a little quartz and mica. The hornblende is the characteristic ingredient, and serves to distinguish sienite from granite, with which it has been sometimes confounded; though the felspar, which is generally red, is the more abundant constituent. The Egyptian sienite, containing but little hornblende, with a good deal of quartz and mica, approaches most nearly to granite. It is equally metalliferous with porphyry; in the island of Cyprus, it is rich in copper; and in Hungary, it contains many valuable gold and silver mines.

Sienite forms a considerable part of the Criffle, a hill in Galloway. It takes its name from the city of Syene, in the Thebaid, near the cataracts of the Nile, where this rock abounds. It is an excellent building-stone, and was imported in large quantities from Egypt by the Romans, for the architectural and statuary decorations of their capital.

SILESIA LINENS. The manufacture of linens is carried on in Bohemia, Moravia, Silesia, and Galicia on the largest scale. Of the entire production about five-twelfths are brought into the market, and of this quantity the bulk must be of domestic manufacture, since few great linen manufactories exist in Austria. Among the linen fabrics, table-cloths and napkins, veils, cambrics, dimities, twills, and drills are important articles. In the next rank we must place the manufacture of thread, especially in Bohemia, Moravia, and Lombardy. The tape manufacture is of less consequence; and as to the business of dyeing and printing, that has been almost entirely absorbed by the cotton manufacture, and is now in requisition for thread and handkerchiefs only.

As the loss resulting from the processes of weaving, bleaching, &c. is estimated at about 10 per cent., the net aggregate of these manufactures of linen thread, &c., may be assumed at, say, 1,037,000 cwt.; of which quantity about 450,000 cwt. come into the market, the rest being absorbed by domestic consumption. Since, upon an average of the five years from 1843 to 1847, there appear to have been imported from abroad only 242 cwt., whereas the average of exports for the same period shows 42,609 cwt., it follows that there remained for home consumption about 1,000,000 cwt. Thus, on a population of 38,000,000 of persons about 2½ lbs. would fall to the share of each; but this estimate falls much below the truth, when we consider that the national costume in Hungary and Galicia requires more than double the quantity we have allowed for. In fact the crop of flax is estimated to be 10 per cent. higher than is given in the official reports; but the consumption of even 3 lbs. per head, which would thus result, is yet smaller than in reality it must be. In the imperial army the quantity used up annually by each man averages more than 7 lbs.

In the above statistics of the manufacture of linen goods no allowance has been made for the extensive production of rope work and the like.

SILICA and SILICON. (*Silica, silicium*, Fr.; *Kieselerde, kiesel*, Germ.) Silica was till lately ranked among the earths proper; but since the researches of Davy and Berzelius, it has been transferred to the chemical class of acids. It constitutes the principal portion of most of the hard stones and minerals which compose the crust of the globe; occurring nearly pure in rock crystal, quartz, agate, calcedony, flint, &c. Silica or silicic acid may be obtained perfectly pure, and also in the finest state of comminution, by taking the precipitate formed by passing silicated fluoric gas through water, filtering, washing, and igniting it, to expel the last traces of the fluoride of silicon. The powder thus obtained is so light as to be blown away with the least breath of air. Silica may be more conveniently procured, however, by fusing ground flint with four times its weight of a mixture, in equal parts, of dry carbonate of potassa and carbonate of soda, in a platinum or silver crucible. The alkaline carbonates should be first fused, and the flint powder sprinkled into the liquid as long as it dissolves with effervescence. The mass is to be then allowed to cool, dissolved in dilute muriatic acid; the solution is to be filtered and evaporated to dryness; the dry crust is to be pulverized, digested for two hours with a little muriatic acid, to remove any iron and alumina that may be present, next washed with hot water, drained, dried, and ignited.

The above silicate of potassa and soda is the compound called soluble glass, which applied in solution to the surface of wood, calico, paper, &c., renders them unsusceptible of taking fire on the contact of an ignited body.

Silica, as thus prepared, is a white powder, rough to the touch, gritty between the teeth, absolutely insoluble in water, acids, and most liquids. Its specific gravity is 2.66. It cannot be fused by the most intense heat of our furnaces, but at the flame of the oxy-hydrogen blowpipe it melts into a limpid colourless glass. By peculiar chemical methods, an aqueous solution of it may be made artificially, similar to what nature presents us with in many thermal springs, as in those of Reikum and of Geyser in Iceland, and of most mineral waters, in minute quantity. There is no acid except the fluoric which can directly dissolve dry or calcined silica. Silica is composed of 48.04 silicon and 51.96 oxygen.

SILICATES, are compounds of silicic acid (silica), with the bases alumina, lime, magnesia, potassa, soda, &c. They constitute the greater number by far of the hard minerals which encrust the terrestrial globe. Thus cyanite is a subsilicate of alumina; felspar and leucite are silicates of alumina and potassa; albite and analcime are silicates of alumina and soda; stilbite, prehnite, mesolite, labradorite, tourmaline, mica, &c., are silicates of alumina and lime: chrysolite, steatite, serpentine, and meerschaum, are silicates of magnesia; augite and hornblende are silicates of lime and magnesia, &c.

SILICON, called also silicium, may be obtained by burning potassium in silicated fluoris gas. The product of the combustion is a brown cinder, which, on being thrown into water, disengages hydrogen with violence, and lets fall a dark liver-brown powder, upon which water exercises no action. This matter is silicon mixed with a salt of difficult solution, which is composed of fluorine, potassium, and silicon. This salt may, however, be removed by a great deal of washing.

SILK MANUFACTURE. (*Fabrique de sois*, Fr.; *Seidenfabrik*, Germ.) This may be divided into two branches: 1. the production of raw silk; 2. its filature and preparation in the mill, for the purposes of the weaver and other textile artisans. The threads, as spun by the silk-worm, and wound up in its cocoon, are all twins, in consequence of the twin orifice in the nose of the insect through which they are projected. These two threads are laid parallel to each other, and are glued more or less evenly together by a kind of glossy varnish, which also envelopes them, constituting nearly 25 per cent. of their weight. Each ultimate filament measures about $\frac{1}{1000}$ of an inch in average fine silk, and the pair measures of course fully $\frac{1}{500}$ of an inch. In the raw silk, as imported from Italy, France, China, &c., several of these twin filaments are slightly twisted and agglutinated to form one thread, called a single.

The specific gravity of silk is 1.300, water being 1.000. It is by far the most tenacious or the strongest of all textile fibres, a thread of it of a certain diameter being nearly three times stronger than a thread of flax, and twice stronger than hemp. Some varieties of silk are perfectly white, but the general colour in the native state is a golden yellow.

The production of silk was unknown in Europe till the sixth century, when two monks, who brought some eggs of the silkworm from China or India to Constantinople, were encouraged to breed the insect, and cultivate its cocoons, by the Emperor Justinian. Several silk manufactures were in consequence established in Athens, Thebes, and Corinth, not only for rearing the worm upon mulberry-leaves, but for unwinding its cocoons, for twisting their filaments into stronger threads, and weaving these into robes. The Venetians having then and long afterwards intimate commercial relations with the Greek empire, supplied the whole of western Europe with silk goods, and derived great riches from the trade.

About 1130, Roger II., king of Sicily, set up a silk manufacture at Palermo, and another in Calabria, conducted by artisans whom he had seized and carried off as prisoners of war in his expedition to the Holy Land. From these countries, the silk industry soon spread throughout Italy. It seems to have been introduced into Spain at a very early period, by the Moors, particularly in Murcia, Cordova, and Granada. The last town, indeed, possessed a flourishing silk trade when it was taken by Ferdinand in the 15th century. The French having been supplied with workmen from Milan, commenced, in 1521, the silk manufacture; but it was not till 1564 that they began successfully to produce the silk itself, when Traucat, a working gardener at Nismes, formed the first nursery of white mulberry-trees, and with such success, that in a few years he was enabled to propagate them over many of the southern provinces of France. Prior to this time, some French noblemen on their return from the conquest of Naples, had introduced a few silkworms with the mulberry into Dauphiny; but the business had not prospered in their hands. The mulberry plantations were greatly encouraged by Henry IV.; and since then they have been the source of most beneficial employment to the French people. James I. was most solicitous to introduce the breeding of silkworms into England, and in a speech from the throne he earnestly recommended his subjects to plant mulberry-trees; but he totally failed in the project. This country does not seem to be well adapted for this species of husbandry, on account of the great prevalence of blighting east winds during the months of April and May, when the worms require a plentiful supply of mulberry-leaves. The manufacture of silk goods, however, made great progress during that king's peaceful and pompous reign. In 1629 it had become so considerable in London that the silk-throwsters of the city and suburbs were formed into a public corporation. So early as 1661 they employed 40,000 persons. The revocation of the edict of Nantes, in 1685, contributed in a remarkable manner to the increase of the English silk trade, by the influx of a large colony of skilful French weavers who settled in Spitalfields. The great silk-throwing mill mounted at Derby, in 1719, also served to promote the extension of this branch of manufacture; for soon

afterwards, in the year 1730, the English silk goods bore a higher price in Italy than those made by the Italians, according to the testimony of Keyser.

Till the year 1826, however, our silk manufactures in general laboured under very grievous fiscal burdens. Foreign organzine, or twisted raw silk, paid an import duty of 14s. 7½d. per pound; raw Bengal silk, 4s.; and that from other places, 5s. 7½d. Mr. Huskisson introduced a bill at that time, reducing the duty on organzine to 5s., and the duty on other raw silk to 3d. per pound. The total prohibition of the import of French manufactured silks, which gave rise to so much contraband trade, was also converted into a duty of 30 per cent. *ad valorem*. During the reign of the prohibitory system, when our silk weavers had no variety of patterns to imitate, and no adequate stimulus to excel, on account of the monopoly which they possessed in the home market, the inferiority of their productions was a subject of constant pride and congratulation among the Lyonnais; and accordingly the English could not stand their competition any where. At that time, the disadvantage on English silk goods, compared to French, was estimated in foreign markets at 40 per cent.; of late years it certainly does not exceed 20, and on plain silks much less, notwithstanding the many peculiar facilities which France enjoys for this her favourite staple.

The silkworm, called by entomologists *Phalena bombyx mori*, is, like its kindred species, subject to four metamorphoses. The egg, fostered by the genial warmth of spring, sends forth a caterpillar, which, in its progressive enlargement, casts its skin either three or four times, according to the variety of the insect. Having acquired its full size in the course of 25 or 30 days, and ceasing to eat during the remainder of its life, it begins to discharge a viscid secretion, in the form of pulpy twin filaments, from its nose, which harden in the air. These threads are instinctively coiled into an ovoid nest round itself, called a cocoon, which serves as a defence against living enemies and changes of temperature. Here it soon changes into the chrysalis or nymph state, in which it lies swaddled, as it were, for about 15 or 20 days. Then it bursts its carments, and comes forth furnished with appropriate wings, antennæ, and feet, for living in its new element, the atmosphere. The male and the female moths couple together at this time, and terminate their union by a speedy death, their whole existence being limited to two months. The cocoons are completely formed in the course of three or four days; the finest being reserved as seed worms. From these cocoons, after an interval of 18 or 20 days, the moth makes its appearance, perforating its tomb by knocking with its head against one end of the cocoon, after softening it with saliva, and thus rendering the filaments more easily torn asunder by its claws. Such moths or aurelias are collected and placed upon a piece of soft cloth, where they couple and lay their eggs.

The eggs, or grains as they are usually termed, are enveloped in a liquid which causes them to adhere to the piece of cloth or paper on which the female lays them. From this glue they are readily freed, by dipping them in cold water, and wiping them dry. They are best preserved in the *ovum* state at a temperature of about 55° F. If the heat of spring advances rapidly in April, it must not be suffered to act on the eggs, otherwise it might hatch the caterpillars long before the mulberry has sent forth its leaves to nourish them. Another reason for keeping back their incubation is, that they may be hatched together in large broods, and not by small numbers in succession. The eggs are made up into small packets, of an ounce, or somewhat more, which in the south of France are generally attached to the girdles of the women during the day, and placed under their pillows at night. They are, of course, carefully examined from time to time. In large establishments, they are placed in an appropriate stove-room, where they are exposed to a temperature gradually increased till it reaches the 86th degree of Fahrenheit's scale, which term it must not exceed. Aided by this heat, nature completes her mysterious work of incubation in eight or ten days. The teeming eggs are now covered with a sheet of paper pierced with numerous holes, about one-twelfth of an inch in diameter. Through these apertures the new-hatched worms creep upwards instinctively, to get at the tender mulberry leaves strewed over the paper.

The nursery where the worms are reared, is called by the French a *magnanière*; it ought to be a well-aired chamber, free from damp, excess of cold or heat, rats and other vermin. It should be ventilated occasionally, to purify the atmosphere from the noisome emanations produced by the excrements of the caterpillars and the decayed leaves. The scaffolding of the wicker-work shelves should be substantial; and they should be from 15 to 18 inches apart. A separate small apartment should be allotted to the sickly worms. Immediately before each moulting, the appetite of the worms begins to flag; it ceases altogether at that period of cutaneous metamorphosis, but revives speedily after the skin is fairly cast, because the internal parts of the animal are thereby allowed freely to develop themselves. At the end of the second age, the worms are half an inch long; and should then be transferred from the small room in which they were first hatched, into the proper apartment where they are to

be brought to maturity and set to spin their balls. On occasion of changing their abode, they must be well cleansed from the litter, laid upon beds of fresh leaves, and supplied with an abundance of food every six hours in succession. In shifting their bed, a piece of network being laid over the wicker plates, and covered with leaves, the worms will creep up over them; when they may be transferred in a body upon the net. The litter, as well as the sickly worms, may thus be readily removed, without handling a single healthy one. After the third age, they may be fed with entire leaves; because they are now exceedingly voracious, and must not be subsequently stinted in their diet. The exposure of chloride of lime, spread thin upon plates, to the air of the *magnanière*, has been found useful in counteracting the tendency which sometimes appears of an epidemic disease among the silkworms, from the fetid exhalations of the dead and dying.

When they have ceased to eat, either in the fourth or fifth age, agreeably to the variety of the *bombyx*, and when they display the spinning instinct by crawling up among the twigs of henth, &c., they are not long of beginning to construct their cocoons, by throwing the thread in different directions, so as to form the *floss*, *flosselle*, or outer open network, which constitutes the *bourre* or silk for carding and spinning.

The cocoons destined for filature, must not be allowed to remain for many days with the worms alive within them; for should the chrysalis have leisure to grow mature or come out, the filaments at one end would be cut through, and thus lose almost all their value. It is therefore necessary to extinguish the life of the animal by heat, which is done either by exposing the cocoons for a few days to sunshine, by placing them in a hot oven, or in the steam of boiling water. A heat of 202° F. is sufficient for effecting this purpose, and it may be best administered by plunging tin cases filled with the cocoons into water heated to that pitch.

80 pounds French (88 Eng.) of cocoons, are the average produce from one ounce of eggs, or 100 from one ounce and a quarter; but M. Folzer of Alsace obtained no less than 165 pounds. The silk obtained from a cocoon is from 750 to 1150 feet long. The varnish by which the coils are glued slightly together, is soluble in warm water.

The silk husbandry, as it may be called, is completed in France within six weeks from the end of April, and thus affords the most rapid of agricultural returns, requiring merely the advance of a little capital for the purchase of the leaf. In buying up cocoons, and in the filature, indeed, capital may be often laid out to great advantage. The most hazardous period in the process of breeding the worms, is at the third and fourth moulting; for upon the 6th day of the third age, and the seventh day of the fourth, they in general eat nothing at all. On the first day of the fourth age, the worms proceeding from one ounce of eggs will, according to Bonafons, consume upon an average twenty-three pounds and a quarter of mulberry leaves; on the first of the fifth age, they will consume forty-two pounds; and on the sixth day of the same age, they acquire their maximum voracity, devouring no less than 223 pounds. From this date their appetite continually decreases, till on the tenth day of this age they consume only fifty-six pounds. The space which they occupy upon the wicker tables, being at their birth only nine feet square, becomes eventually 239 feet. In general, the more food they consume, the more silk will they produce.

A mulberry-tree is valued, in Provence, at from 6*d.* to 10*d.*; it is planted out of the nursery at four years of age; it is begun to be stripped in the fifth year, and affords an increasing crop of leaves till the twentieth. It yields from 1 cwt. to 30 cwt. of leaves, according to its magnitude and mode of cultivation. One ounce of silkworm eggs is worth in France about 2½ francs; it requires for its due development into cocoons about 15 cwt. of mulberry leaves, which cost upon an average 3 francs per cwt. in a favourable season. One ounce of eggs is calculated, as I have said, to produce from 80 to 100 pounds of cocoons, of the value of 1 fr. 52 centimes per pound, or 125 francs in whole. About 8 pounds of reeled raw silk, worth 18 francs a pound, are obtained from these 100 pounds of cocoons.

There are three denominations of raw silk; viz., *organzine*, *trame* (shute or tram), and *floss*. *Organzine* serves for the warp of the best silk stuffs, and is considerably twisted; *trame* is made usually from inferior silk, and is very slightly twisted, in order that it may spread more, and cover better in the web; *floss*, or *bourre*, consists of the shorter broken silk, which is carded and spun like cotton. *Organzine* and *trame* may contain from 3 to 30 twin filaments of the worm; the former possesses a double twist, the component filaments being first twisted in one direction, and the compound thread in the opposite; the latter receives merely a slender single twist. Each twin filament gradually diminishes in thickness and strength, from the surface of the cocoon, where the animal begins its work in a state of vigour, to the centre, where it finishes it, in a state of debility and exhaustion; because it can receive no food from the moment of its beginning to spin by spouting forth its silky substance. The winder is attentive to this progressive attenuation, and introduces the commencement of some cocoons to compensate for the

termination of others. The quality of raw silk depends, therefore, very much upon the skill and care bestowed upon its filature. The softest and purest water should be used in the cocoon kettle.

The quality of the raw silk is determined by first winding off 400 ells of it, equal to 475 metres, round a drum one ell in circumference, and then weighing that length. The weight is expressed in grains, 24 of which constitute one denier; 24 deniers constitute one ounce; and 16 ounces make one pound, *poinds de marc*. This is the Lyons rule for valuing silk. The weight of a thread of raw silk 400 ells long, is two grains and a half, when five twin filaments have been reeled and associated together.

Raw silk is so absorbent of moisture, that it may be increased ten per cent. in weight by this means. This property has led to falsifications; which are detected by enclosing weighed portions of the suspected silk in a wire-cloth cage, and exposing it to a stove-heat of about 78° F. for 24 hours, with a current of air. The loss of weight which it thereby undergoes, demonstrates the amount of the fraud. There is an office in Lyons called the *Condition*, where this assay is made, and by the report of which the silk is bought and sold. The law in France requires, that all the silk tried by the *Condition* must be worked up into fabrics in that country.

In the Journal of the Asiatic Society of Bengal, for January, 1837, there are two very valuable papers upon silkworms; the first, upon those of Assam, by Mr. Thomas Hugon, stationed at Nowgong; the second by Dr. Helfer, upon those which are indigenous to India. Besides the *Bombyx mori*, the Doctor enumerates the following seven species, formerly unknown:—1. The wild silkworm of the central provinces, a moth not larger than the *Bombyx mori*. 2. The Joree silkworm of Assam, *Bombyx religiosa*, which spins a cocoon of a fine filament, with much lustre. It lives upon the pipul tree (*Ficus religiosa*), which abounds in India, and ought therefore to be turned to account in breeding this valuable moth. 3. *Saturnia silhetica*, which inhabits the Cassia mountains in Silhet and Dacca, where its large cocoons are spun into silk. 4. A still larger *Saturnia*, one of the greatest moths in existence, measuring ten inches from the one end of the wing to the other; observed by Mr. Grant, in *Chirra Panjee*. 5. *Saturnia paphia*, or the Tusseh silkworm, is the most common of the native species, and furnishes the cloth usually worn by Europeans in India. It has not hitherto been domesticated, but millions of its cocoons are annually collected in the jungles, and brought to the silk factories near Calcutta and Bhagelpur. It feeds most commonly on the hair-tree (*Zizyphus jujuba*), but it prefers the *Terminalia alata*, or Assam tree, and the *Bombax heptaphyllum*. It is called *Koutkuri mooga*, in Assam. 6. Another *Saturnia*, from the neighbourhood of Comereolly. 7. *Saturnia assamensis*, with a cocoon of a yellow-brown colour, different from all others, called *mooga*, in Assam; which, although it can be reared in houses, thrives best in the open air upon trees, of which seven different kinds afford it food. The *Mazankoory mooga*, which feeds on the Adakoory tree, produces a fine silk, which is nearly white, and fetches 50 per cent. more than the fawn-coloured. The trees of the first year's growth produce by far the most valuable cocoons. The *mooga* which inhabits the soom-tree, is found principally in the forests of the plains, and in the villages. The tree grows to a large size, and yields three crops of leaves in the year. The silk is of a light fawn colour, and ranks next in value to the Mazankoory. There are generally five breeds of *mooga* worms in the year; 1. in January and February; 2. in May and June; 3. in June and July; 4. in August and September; 5. in October and November; the first and last being the most valuable.

The Assamese select for breeding, such cocoons only as have been begun to be formed in the largest number on the same day, usually the second or third after the commencement; those which contain males being distinguishable by a more pointed end. They are put in a closed basket suspended from the roof; the moths, as they come forth, having room to move about, after a day, the females (known only by their large body) are taken out, and tied to small wisps of thatching-straw, selected always from over the hearth, its darkened colour being thought more acceptable to the insect. If out of a batch, there should be but few males, the wisps with the females tied to them are exposed outside at night; and the males thrown away in the neighbourhood find their way to them. These wisps are hung upon a string tied across the roof, to keep them from vermin. The eggs laid after the first three days are said to produce weak worms. The wisps are taken out morning and evening, and exposed to the sunshine, and in ten days after being laid, a few of them are hatched. The wisps being then hung up to the tree, the young worms find their way to the leaves. The ants, whose bite is fatal to the worm in its early stages, are destroyed by rubbing the trunk of the tree with mollasses, and tying dead fish and toads to it, to attract these rapacious insects in large numbers, when they are destroyed with fire; a process which needs to be repeated several times. The ground under the trees is also well cleared, to render it easy to pick up and replace the worms which fall down. They are prevented from coming to

the ground by tying fresh plantain-leaves round the trunk, over whose slippery surfs they cannot crawl; and they are transferred from exhausted trees to fresh ones, on bamboo platters tied to long poles. The worms require to be constantly watched and protected from the depredations of both day and night birds, as well as rats and other vermin. During their moultings, they remain on the branches; but when about beginning to spin, they come down the trunk, and being stopped by the plantain-leaves, are there collected in baskets, which are afterwards put under bunches of dry leaves, suspended from the roof, into which the worms crawl, and form their cocoons—several being clustered together: this accident, due to the practice of crowding the worms together, which is most injudicious, rendering it impossible to wind off their silk in continuous threads, as in the filatures of Italy, France, and even Bengal. The silk is, therefore, spun like flax, instead of being unwound in single filaments. After four days the proper cocoons are selected for the next breed, and the rest are uncoiled. The total duration of a breed varies from 60 to 70 days; divided into the following periods:—

| | | | | |
|---|---|---|---|----|
| Four moultings, with one day's illness attending each | - | - | - | 30 |
| From fourth moulting to beginning of cocoon | - | - | - | 10 |
| In the cocoon 20, as a moth 6, hatching of eggs 10 | - | - | - | 36 |

—
66

On being tapped with the finger, the body renders a hollow sound; the quality of which shows whether they have come down for want of leaves on the tree, or from their having ceased feeding.

As the chrysalis is not soon killed by exposure to the sun, the cocoons are put on stages, covered up with leaves, and exposed to the hot air from grass burned under them; they are next boiled for about an hour in a solution of the potash, made from incinerated rice-stalks; then taken out, and laid on cloth folded over them to keep them warm. The floss being removed by hand, they are then thrown into a basin of hot water to be unwound; which is done in a very rude and wasteful way.

The plantations for the mooga silkworm in Lower Assam, amount to 5000 acres, besides what the forests contain; and yield 1500 maunds of 84 lbs. each per annum. Upper Assam is more productive.

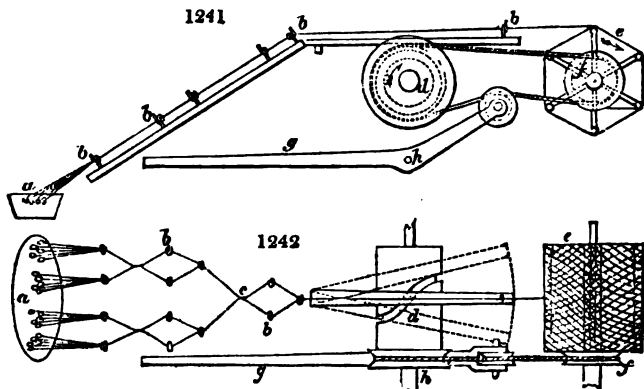
The cocoon of the *Kontkuri mooga* is of the size of a fowl's egg. It is a wild species, and affords filaments much valued for fishing-lines. See SILKWORM GUT.

8. The *Arrindy*, or *Eria* worm, and moth, is reared over a great part of Hindustan, but entirely within doors. It is fed principally on the *Hera*, or *Pelas christi* leaves, and gives sometimes 12 broods of spun silk in the course of a year. It affords a fibre which looks rough at first; but when woven, becomes soft and silky, after repeated washings. The poorest people are clothed with stuff made of it, which is so durable as to descend from mother to daughter. The cocoons are put in a closed basket, and hung up in the house, out of reach of rats and insects. When the moths come forth, they are allowed to move about in the basket for twenty-four hours; after which the females are tied to long reeds or canes, twenty or twenty-five to each, and these are hung up in the house. The eggs that are laid the first three days, amounting to about 200, alone are kept; they are tied up in a cloth, and suspended to the roof till a few begin to hatch. These eggs are white, and of the size of turnip-seed. When a few of the worms are hatched, the cloths are put on small bamboo platters hung up in the house, in which they are fed with tender leaves. After the second moulting, they are removed to bunches of leaves suspended above the ground, beneath which a mat is laid to receive them when they fall. When they cease to feed, they are thrown into baskets full of dry leaves, among which they form their cocoons, two or three being often found joined together. Upon this injudicious practice I have already animadverted.

9. The *Saturnia trifenestrata*, has a yellow cocoon of a remarkably silky lustre. It lives on the soom-tree in Assam, but seems not to be much used.

The mechanism of the silk filature, as lately improved in France, is very ingenious. Figs. 1241 and 1242. exhibit it in plan and longitudinal view. *a* is an oblong copper basin containing water heated by a stove or by steam. It is usually divided by transverse partitions into several compartments, containing 20 cocoons, of which there are 5 in one group, as shown in the figure. *b, b*, are wires with hooks or eyelets at their ends, through which the filaments run, apart, and are kept from ravelling. *c, c*, the points where the filaments cross and rub each other, on purpose to clean their surfaces. *d*, is a spiral groove, working upon a pin point, to give the traverse motion alternately to right and left, whereby the thread is spread evenly over the surface of the reel *e*. *f, f*, are the pulleys, which by means of cords transmit the rotatory movement of the cylinder *d*, to the reel *e*. *g*, is a friction lever or tumbler, for lightening or slackening the endless

cord, in the act of starting or stopping the winding operation. Every apartment of a large filature contains usually a series of such reels as the above, all driven by one prime mover; each of which, however, may by means of the tumbling lever be stopped at



pleasure. The reeler is careful to remove any slight adhesions, by the application of a brush in the progress of her work.

The expense of reeling the excellent Cevennes silk is only 3 francs and 50 centimes per Alais pound; from 4 to 5 cocoons going to one thread. That pound is 92 hundredths of our avoirdupois pound. In Italy, the cost of reeling silk is much higher, being 7 Italian livres per pound, when 3 to 4 cocoons go to the formation of one thread; and 6 livres when there are from 4 to 5 cocoons. The first of these raw silks will have a titre of 20 to 24 deniers; the last, of 24 to 28. If 5 to 6 cocoons go to one thread, the titre will be from 26 to 32 deniers, according to the quality of the cocoons. The Italian livre is worth $7\frac{1}{4}$ d. English. The woman employed at the kettle receives one livre and five sous per day; and the girl who turns the reel, gets thirteen sous a day; both receiving board and lodging in addition. In June, July, and August, they work 16 hours a day, and then they wind a *rube* or ten pounds weight of cocoons, which yield from 1-5th to 1-6th of silk, when the quality is good. The whole expenses amount to from 6 to 7 livres upon every ten pounds of cocoons; which is about 2s. 8d. per English pound of raw silk.

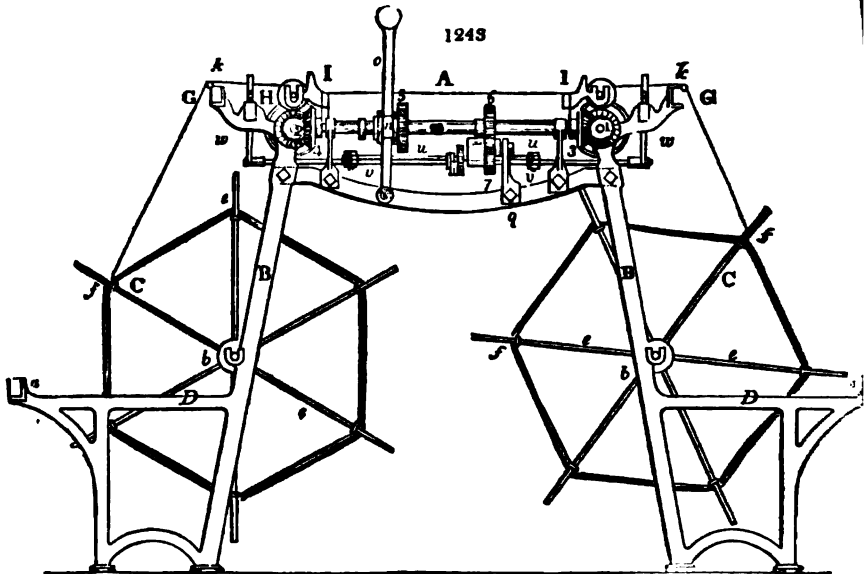
The raw silk, as imported into this country in hanks from the filatures, requires to be regularly wound upon bobbins, doubled, twisted, and reeled in our silk-mills. These processes are called *throwing* silk, and their proprietors are called *silk throwsters*; terms probably derived from the appearance of swinging or tossing which the silk threads exhibit during their rapid movements among the machinery of the mills.

A representation of a French mill for throwing silk, is given in the *Dictionnaire Technologique*, under the article *Mouillage de Soie*. But it is a most awkward, operose, and defective piece of machinery, quite unworthy of being presented to my readers. It was in Manchester that throwing-mills received the grand improvement upon the ancient Italian plan, which had been originally introduced into this country by Sir Thomas Lombe, and erected at Derby. That improvement is chiefly due to the eminent factory engineers, Messrs. Fairbairn and Lillie, who transferred to silk the elegant mechanism of the throstle, so well known in the cotton trade. Still, throughout the silk districts of France the throwing mills are generally small, not many of them turning off more than 1000 pounds of organzine per annum, and not involving 5000*l.* of capital. The average price of throwing organzine in that country, where the throwster is not answerable for loss, is 7 francs; of throwing trame, from 4 fr. to 5 fr. (per kilogramme?) Where the throwster is accountable for loss, the price is from 10 fr. to 11 fr. for organzine, and from 6 to 7 for trame. In Italy, throwing adds 3s. 9d. to the price of raw silk, upon an average. I should imagine, from the perfection and speed of the silk-throwing machinery in this country, as about to be described, that the cost of converting a pound of raw silk either into organzine or trame must be considerably under any of the above sums.

SILK-THROWING MILL.

The first process to which the silk is subjected, is winding the skeins, as imported, off upon bobbins. The mechanism which effects this winding off and on, is technically called the *engine*, or *swift*. The bobbins to which the silk is transferred, are wooden

cylinders, of such thickness as may not injure the silk by sudden flexure, and which may also receive a great length of thread without having their diameter materially increased, or their surface velocity changed. Fig. 1243. is an end view of the silk-throwing machine, or engine, in which the two large hexagonal reels, called swifts, are



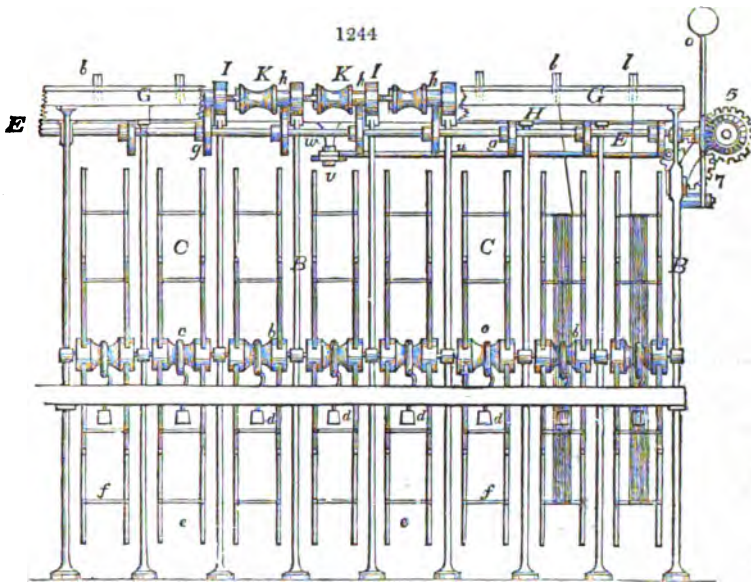
seen in section, as well as the table between them, to which the bobbins and impelling mechanism are attached. The skeins are put upon these reels, from which the silk is gradually unwound by the traction of the revolving bobbins. One principal object of attention, is to distribute the thread over the length of the bobbin-cylinder in a spiral or oblique direction, so that the end of the slender semi-transparent thread may be readily found when it breaks. As the bobbins revolve with uniform velocity, they would soon wind on too fast, were their diameters so small at first as to become greatly thicker when they are filled. They are therefore made large, are not covered thick, but are frequently changed. The motion is communicated to that end of the engine shown in the figure.

The wooden table *A*, shown here in cross section, is sometimes of great length, extending 20 feet, or more, according to the size of the apartment. Upon this the skeins are laid out. It is supported by the two strong slanting legs *B*, *B*, to which the bearings of the light reel *C* are made fast. These reels are called *swifts*, apparently by the same etymological casuistry as *lucus à non lucendo*; for they turn with reluctant and irregular slowness; yet they do their work much quicker than any of the old apparatus, and in this respect may deserve their name. At every eighth or tenth leg there is a projecting horizontal piece *D*, which carries at its end another horizontal bar *E*, called the knee rail, at right angles to the former. This protects the slender reels or swifts from the knees of the operatives.

These swifts have a strong wooden shaft *b*, with an iron axis passing longitudinally through it, round which they revolve, in brass bearings fixed near to the middle of the legs *B*. Upon the middle of the shaft *b*, a loose ring is hung, shown under *c*, in *fig.* 1244, to which a light weight *d*, is suspended, for imparting friction to the reel, and thus preventing it from turning round, unless it be drawn with a gentle force, such as the traction of the thread in the act of winding upon the bobbin.

Fig. 1244. is a front view of the engine. *B*, *B*, are the legs, placed at their appropriate distances (scale 1½ inch to the foot); *C*, *C*, are the swifts. By comparing *figs.* 1243, and 1244. the structure of the swifts will be fully understood. From the wooden shaft *b*, six slender wooden (or iron) spokes *e*, *e*, proceed, at equal angles to each other; which are bound together by a cord *f*, near their free ends, upon the transverse line *f* of which cord, the silk thread is wound, in a hexagonal form; due tension being given to the circumferential cords, by sliding them out from the centre. Slender wooden rods

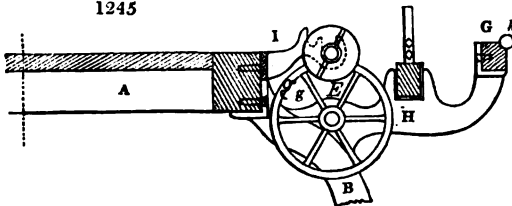
are set between each pair of spokes, to stay them, and to keep the cord tight. *x* is one of the two horizontal shafts, placed upon each side of the engine, to which are affixed



a number of light iron pulleys *g, g* (shown on a double scale in *fig. 1245*). These serve, by friction, to drive the bobbins which rest upon their peripheries.

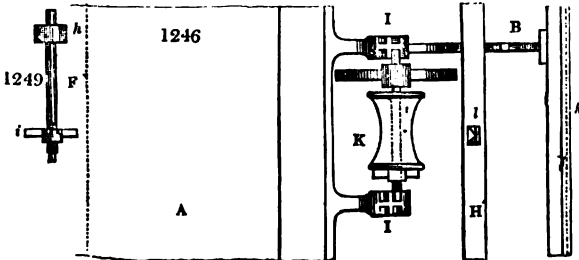
To the table *A*, *fig. 1243*., are screwed the light cast-iron slot-bearings *i, i*, wherein the horizontal spindles or skewers rest, upon which the bobbins revolve. The spindles (see *r*, *fig. 1249*.) carry upon one end a little wooden pulley *h*, whereby they press and revolve upon the larger driving pulleys *g*, of the shaft *x*. These pulleys are called *stars* by our workmen. The other ends of the spindles, or skewers, are cut into screws, for attaching the swivel nuts *i* (*fig 1249*-), by which the bobbins *x, x*, are made fast to their respective spindles.

1245



Besides the slots, above described, in which the spindles rest when their friction pulleys *h*, are in contact with the moving stars *g*, there is another set of slots in the bearings, into which the ends of the spindles may be occasionally laid, so as to be above the line of contact of the rubbing periphery of the star *g*, in case the thread of any bobbin breaks. Whenever the girl has mended the thread, she replaces the bobbin-spindle in its deeper slot-bearings, thereby bringing its pulley once more into contact with the star, and causing it to revolve.

g is a long ruler or bar of wood, which is supported upon every eighth or twelfth leg *x, x*. (The figure being, for convenience of the page, contracted in length, shows it at every sixth leg.) To the edge of that bar the smooth glass rods *h*, are made fast, over which the threads glide from the swifts, in

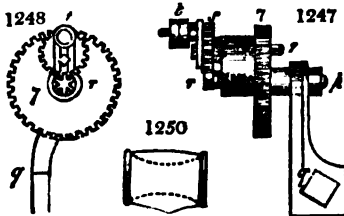


g is a long ruler or bar of wood, which is supported upon every eighth or twelfth leg *x, x*. (The figure being, for convenience of

the page, contracted in length, shows it at every sixth leg.) To the edge of that bar the smooth glass rods *h*, are made fast, over which the threads glide from the swifts, in

their way to the bobbins. *m* is the guide bar, which has a slow traverse or saw motion, sliding in slots at the top of the legs *a*, where they support the bars *a*. Upon the guide bar *m*, the guide pieces *l, l*, are made fast. These consist of two narrow, thin, upright plates of iron, placed endwise together, their contiguous edges being smooth, parallel, and capable of approximation to any degree by a screw, so as to increase or diminish at pleasure the ordinary width of the vertical slit that separates them. Through this slit the silk thread must pass, and, if rough or knotty, will be either cleaned or broken; in the latter case, it is neatly mended by the attendant girl.

The motions of the various parts of the *engine* are given as follows. Upon the end of the machine, represented in *fig. 1243*, there are attached to the shafts *x* (*fig. 1244*), the bevel wheels 1 and 2, which are set in motion by the bevel wheels 3 and 4, respectively. These latter wheels are fixed upon the shaft *m*, *fig. 1243*, *m* is moved by the main steam shaft which runs parallel to it, and at the same height, through the length of the *engine* apartment, so as to drive the whole range of the machines. 5 is a loose wheel or pulley upon the shaft *m*, working in gear with a wheel upon the steam shaft, and which may be connected by the clutch *s*, through the hand lever or gearing rod *o* (*figs. 1243* and 1244.), when the engine is to be set at work. 6 is a spur wheel upon the shaft *m*, by which the stud wheel 7, is driven, in order to give the traverse motion to the guide bar *x*. This wheel is represented, with its appendages, in double size, *figs. 1247* and 1248. with its boss upon a stud *p*, secured to the bracket *q*. In an eccentric hole



of the same boss, another stud *r*, revolves, upon which the little wheel *s*, is fixed. This wheel *s* is in gear with a pinion cut upon the end of the fixed stud *p*; and upon it is screwed the little crank *t*, whose collar is connected by two rods *u* (*figs. 1243*, & 1244.), to a cross-piece *w*, which unites the two arms *v*, that are fixed upon the guide bar *x*, on both sides of the machine. By the revolution of wheel 7, the wheel *s* will cause the pinion of the fixed stud *p* to turn round. If that wheel bear to the pinion the

proportion of 4 to 1, then the wheel *s* will make, at each revolution of the wheel 7, one-fourth of a revolution; whereby the crank *t* will also rotate through one-fourth of a turn, so as to be brought nearer to the centre of the stud, and to draw the guide bar so much less to one side of its mean position. At the next revolution of wheel 7, the crank *t* will move through another quadrant, and come still nearer to the central position, drawing the guide bars still less aside, and therefore causing the bobbins to wind on more thread in their middle than towards their ends. The contrary effect would ensue, were the guide bars moved by a single or simple crank. After four revolutions of the wheel 7, the crank *t* will stand once more as shown in *fig. 1248*., having moved the bar *x* through the whole extent of its traverse. The bobbins, when filled, have the appearance represented in *fig. 1250*; the thread having been laid on the mull the time in diagonal lines, so as never to coincide with each other.

Doubling is the next operation of the silk throwster. In this process, the threads of two or three of the bobbins, filled as above, are wound together in contact upon a single bobbin. An ingenious device is here employed to stop the winding-on the moment that one of these parallel threads happens to break. Instead of the swifts or reels, a creel is here mounted for receiving the bobbins from the former machine, two or three being placed in one line over each other, according as the threads are to be doubled or trebled. Though this machine is in many respects like the *engine*, it has some additional parts, whereby the bobbins are set at rest, as above mentioned, when one of the doubling threads gets broken.

Fig. 1251, is an end view, from which it will be perceived that the machine is, like the preceding, a double one, with two working sides.

Fig. 1252, is a front view of a considerable portion of the machine.

Fig. 1253, shows part of a cross section, to explain minutely the mode of winding upon a single bobbin.

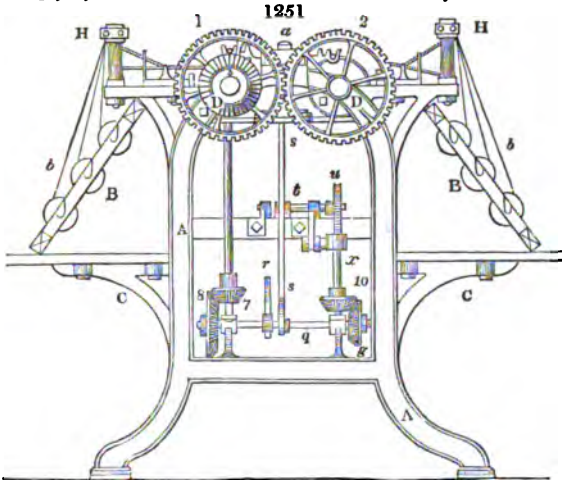
Fig. 1254, is the plan of the parts shown in *fig. 1253*; these two figures being drawn to double the scale of *figs. 1251*. and 1252.

A, A, *figs. 1251*. & 1252., are the end frames, connected at their tops by a wooden stretcher, or *bar-beam*, *a*, which extends through the whole length of the machine; this bar is shown also in *figs. 1253*. and 1254.

B, B, are the creels upon each side of the machine, or bobbin bearers, resting upon wooden beams or boards, made fast to the arms or brackets *c*, about the middle of the frames *A*.

D, D, are two horizontal iron shafts, which pervade the whole machine, and carry a series of light movable pulleys, called *stars*, *c, c*, (*figs. 1253*, 1254.) which serve to drive the

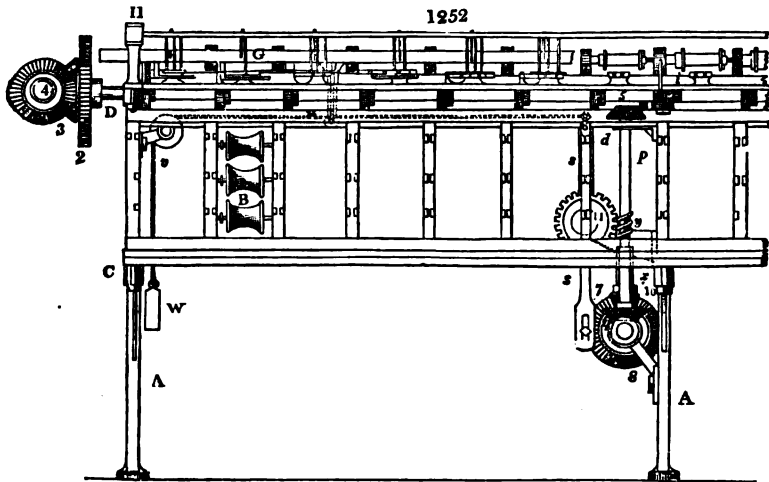
bobbins *x, x*, whose fixed pulleys rest upon their peripheries, and are therefore turned simply by friction. These bobbins are screwed by swivel nuts *e, e*, upon spindles, as in



the silk engine. Besides the small friction pulley or boss, *d*, seen best in *fig. 1254.*, by which they rest upon the star pulleys *c, c*, a little ratchet wheel *f*, is attached to the other end of each bobbin. This is also shown by itself at *f*, in *fig. 1255.*

The spindles with their bobbins revolve in two slot-bearings *r, r*, *fig. 1254.*, screwed to the bar-beam *a*, which is supported by two or three intermediate upright frames, such as *A*. The slot-bearings *r*, have also a second slot, in which the spindle with the

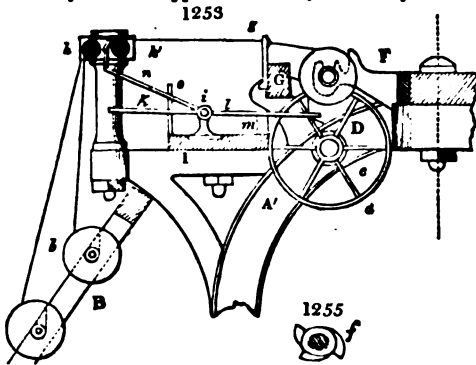
bobbin is laid at rest, out of contact of the star wheel, while its broken thread is being mended. *a* is the guide bar (to which the cleaner slit pieces *g, g*, are attached), for



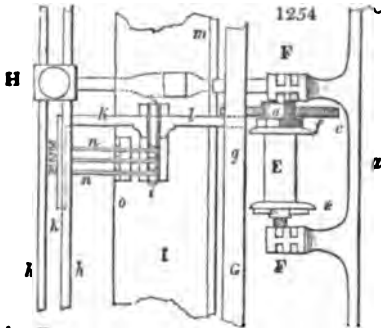
making the thread traverse to the right and the left, for its proper distribution over the surface of the bobbin. The guide bar of the doubling machine is moved with a slower traverse than in the engine; otherwise, in consequence of the different obliquities of the paths, the single threads would be readily broken. *h, h*, is a pair of smooth rods of iron or brass, placed parallel to each of the two sides of the machine, and made fast to the standards *H, H*, which are screwed to brackets projecting from the frames *A, A*. Over these rods the silk threads glide, in their passage to the guide wires *g, g*, and the bobbins *x, x*.

l, l, is the lever board upon each side of the machine, upon which the slight brass bearings or fulcrums *i, i*, one for each bobbin in the reel, are made fast. This board bears the balance-lever *k, l*, with the fallers *n, n, n*, which act as dexterous fingers, and stop the bobbin from winding-on the instant a thread may chance to break. The levers *k, l*, swing upon a fine wire axis, which passes through their props *i, i*, their arms being shaped rectangularly, as shown at *k, k'*, (*1254*). The arm *l*, being heavier than the arm *k*, naturally rests upon the ridge bar *m*, of the lever board *l*. *n, n, n*, are three wires, resting at one of their ends upon the axis of the fulcrum *i, i*, and having each of their other hooked ends suspended by one of the silk threads, as it passes over the front steel rod *h*, and under

A'. These faller wires, or stop fingers, are guided truly in their up-and-down motion with the thread, by a cleaner-plate *o*, having a vertical slit in its middle. Hence, whenever any thread happens to break, in its way to a winding-on bobbin *x*, the wire *z*



which hung by its eyelet end to that thread, as it passed through between the steel rods in the line of *A, A'*, falls upon the lighter arm of the balance lever *k, l*, weighs down that arm *k*, consequently jerks up the arm *l*, which pitches its tip or end into one of the three notches of the ratchet or catch wheel *f* (Figs. 1254, & 1255), fixed to the end of the bobbin. Thus its motion is instantaneously arrested, till the girl has had leisure to mend the thread, when she again bangs up the faller wire *z*, and restores the lever *k, l*, to its horizontal position. If, meanwhile, she took occasion to remove the winding bobbin out of the slot-bearing, where pulley *d* touches the star wheel *c*, into the right-hand upper slot of repose, she must now shift it into its slot of rotation.



The motions are given to the doubling machine in a very simple way. Upon the end of the framing, represented *fig. 1251*, the shafts *n, n'*, bear two spur wheels 1 and 2, which work into each other. To the wheel 1, is attached the bevel wheel 3, driven by another bevel wheel 4 (Fig. 1252), fixed to a shaft that extends the whole length of the apartment, and serves therefore, to drive a whole range of machines. The wheel 4 may be put in gear with the shaft, by a clutch and gear-handle, as in the silk engine, and thereby it drives two shafts, by the one transmitting its movement to the other.

The traverse motion of the guide bar *c*, is effected as follows:— Upon one of the shafts *n*, there is a bevel wheel 5, driving the bevel wheel 6, upon the top of the upright shaft *p* (Fig. 1252., to the right of the middle); whence the motion is transmitted to the horizontal shaft *q*, below, by means of the bevel wheels 7 and 8. Upon this shaft *q*, there is a heart-wheel *r*, working against a roller which is fixed to the end of the lever *s*, whose fulcrum is at *t*, *fig. 1251*. The other end of the lever *s*, is connected by two rods (shown by dotted lines in *fig. 1252*.) to a brass piece which joins the arms *u* (Fig. 1252.), of the guide bars *c*. To the same cross piece a cord is attached, which goes over a roller *v*, and suspends a weight *w*, by means of which the lever *s*, is pressed into contact with the heart-wheel *r*. The fulcrum *t*, of the lever *s*, is a shaft which is turned somewhat eccentric, and has a very slow rotatory motion. Thus the guide bar, after each traverse, necessarily winds the silk in variable lines, to the side of the preceding threads.

The motion is given to this shaft in the following way. Upon the horizontal shaft *q*, there is a bevel wheel *g* (Figs. 1252. & 1253.), which drives the wheel 10 upon the shaft *x*; on whose upper end, the worm *y* works in the wheel 11, made fast to the said eccentric shaft *t*; round which the lever *s*, swings or oscillates, causing the guide bars to traverse.

The spinning silk-mill.— The machine which twists the silk threads, either in their single or doubled state, is called the spinning mill. When the raw singles are first twisted in one direction, next doubled, and then twisted together in the opposite direction, an exceedingly wiry, compact thread, is produced, called *organzine*. In the spinning mill, either the singles or the doubled silk, while being unwound from one set of bobbins, and wound upon another set, is subjected to a regular twisting operation, in which process the thread is conducted as usual through guides, and coiled diagonally upon the bobbins by a proper mechanism.

Fig. 1256. exhibits an end view of the spinning mill; in which four working lines are shown; two tiers upon each side, one above the other. Some spinning mills have

three working tiers upon each side; but as the highest tier must be reached by a ladder or platform, this construction is considered by many to be injudicious.

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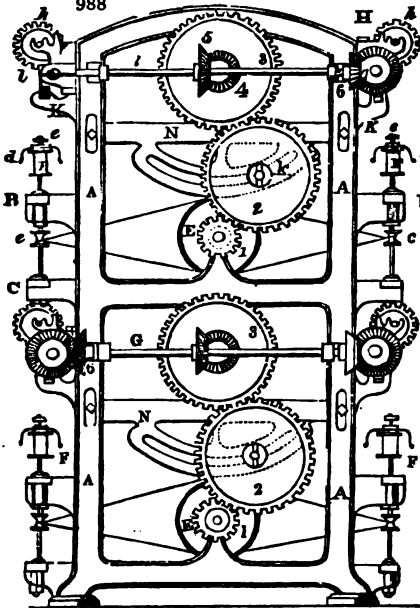


Fig. 1257. is a front view, where, as in the former figure, the two working lines are shown.

Fig. 1258. is a cross section of a part of the machine, to illustrate the construction and play of the working parts; figs. 1264, 65. are other views of Fig. 1258.

Fig. 1259. shows a single part of the machine, by which the bobbins are made to revolve.

Figs. 1260, and 1261. show a different mode of giving the traverse to the guide bars, than that represented in Fig. 1258.

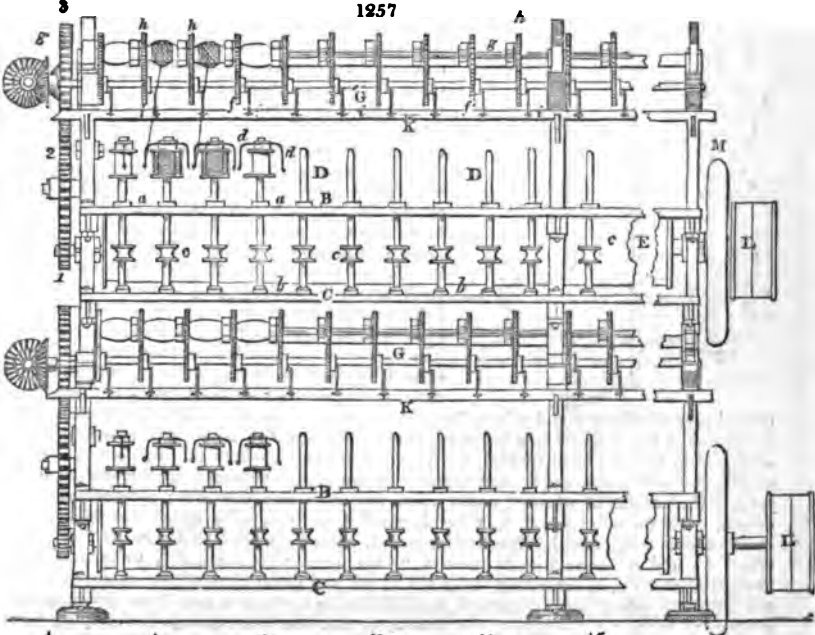
Figs. 1262, & 1263. show the shape of the full bobbins, produced by the action of these two different traverse motions.

The upper part of the machine being exactly the same as the under part, it will be sufficient to explain the construction and operation of one of them.

A, A, are the end upright frames or standards, between which are two or three intermediate standards, according to the length of the machine. They are all connected at their sides by beams B and C, which extend the whole length of the machines. D, D, are the spindles, whose top bearings a, a, are made fast to the beams B, and their bottoms turn in hard brass steps, fixed to the bar C. These two bars together are

are the spindles, whose top bearings a, a, are made fast to the beams B, and their bottoms turn in hard brass steps, fixed to the bar C. These two bars together are

1257



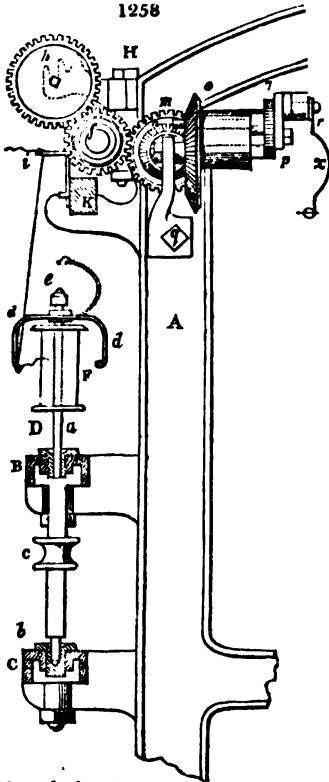
called, by the workmen, the spindle box. The standards *A, A*, are bound with cast bars *n, n*.

c, c, are the wharves or whorls, turned by a band from the horizontal tin cylinder in the lines of *x, x*, *fig. 1256*, lying in the middle line between the two parallel rows of spindles *n, n*. *r, r*, are the bobbins containing the untwisted doubled silk, which are simply pressed down upon the taper end of the spindles. *d, d*, are little flyers or forked wings of wire, attached to washers of wood, which revolve loose upon the tops of the said bobbins *r*, and round the spindles. One of the wings is sometimes bent upwards, to serve as a guide to the silk, as shown by dotted lines in *fig. 1258*. *c, c*, are pieces of wood pressed upon the tops of the spindles, to prevent the flyers from starting off by the centrifugal force. *a, a*, are horizontal shafts bearing a number of little spur wheels *f, f*. *n, n*, are slot-bearings, similar to those of the doubling-machine, which are fixed to the end and middle frames. In these slots, the light square cast-iron shafts or spindles *g, g*, *fig. 1257*, are laid, on whose end the spur wheel *h* is cast; and when the shaft *g* lies in the front slot of its bearing, it is in gear with the wheel *f*, upon the shaft *c*; but when it is laid in the back slot, it is out of gear, and at rest. See *r, r*, *fig. 1254*.

Upon these little cast-iron shafts or spindles *g, g*, *fig. 1259*, the bobbins or blocks *i, i* are thrust, for receiving, by winding-on, the twisted or spun silk. These blocks are made of a large diameter, in order that the silk fibres may not be too much bent; and they are but slightly filed, at each successive charge, lest, by increasing their diameter too much, they should produce too rapid an increase in the rate of winding, with proportional diminution in the twist, and risk of stretching or tearing the silk. They are therefore the more frequently changed. *x, x*, are the guide bars, with the guides *i, i*, through which the silk passes, being drawn by the revolving bobbins *i*, and delivered or laid on by the flyers *d, d*, from the rotatory twisting-bobbins *r*. The operation of the machine is therefore simple, and the motions are given to the parts in a manner equally so.

Upon the shaft of the tin cylinder or drum exterior to the frame, the usual fast and loose pulleys, or riggers, *L, L'*, are mounted, for driving the whole machine. These riggers are often called steam-pulleys by the workmen, from their being connected by bands with the steam-driven shaft of the factory. In order to allow the riggers upon the shafts of the upper and the under drums to be driven from the same pulley upon the main shaft, the axis of the under drum is prolonged at *L, L'*, and supported at its end, directly from the floor, by an upright bearing. Upon the shafts of the tin cylinders there is also a fly-wheel *n*, to equalize the motion. Upon the other ends of these shafts, namely at the end of the spinning-mill, represented in *fig. 1256*, the pinions *1* are fixed, which drive the wheels *3*, by means of the intermediate or carrier wheel *2*; called also the plate wheel, from its being hollowed somewhat like a trencher. *1*, is called the change-pinion, because it is changed for another, of a different size and different number of teeth, when a change in

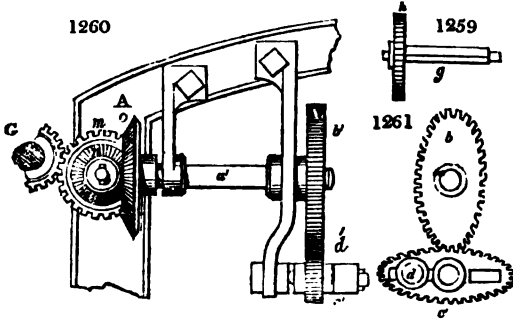
the velocity of wheels 2 and 3 is to be made. To allow a greater or smaller pinion to be applied at *1*, the wheel *2* is mounted upon a stud *k*, which is movable in a slot concentric with the axis of the wheel *3*. This slot is a branch from the cross bar *n*. The smaller the change-pinion is, the nearer will the stud *k* approach to the vertical line joining the centres of wheels *1* and *3*; and the more slowly will the plate wheel *2* be driven. To the spur wheel *3*, a bevel wheel *4*, is fixed, with which the other also revolves loose upon a stud. The bevel wheel *5*, upon the shaft *l*, is driven by the bevel wheel *4*; and it communicates motion, by the bevel wheels *6* and *7*, to each of the horizontal shafts *a, a*, extending along the upper and under tiers of the machine. At the left-hand side of the top part of *fig. 1256*, the two wheels *6* and *7* are omitted, on purpose to show the bearings of the shaft *a*, as also the slot-bearings for carrying the shafts or skewers of the bobbins.



If it be desired to communicate twist in the opposite direction to that which would be given by the actual arrangement of the wheels, it is necessary merely to transpose the carrier wheel 2, from its present position on the right hand of pinion 1, to the left of it, and to drive the tin cylinder by a crossed or close strap, instead of a straight or open one.

The traverse motion of the guide is given here in a similar way to that of the engine, (fig. 1249. Near one of the middle or cross-frames of the machine (see fig. 1258,) the wheel *f*, in gear with a spur wheel *h*, upon one of the block-shafts, drives also a spur wheel *m*, that revolves upon a stud, to which wheel is fixed a bevel wheel *n*, in gear with the bevel wheel *o*. To wheel *o*, the same mechanism is attached as was described under figs. 1247. and 1248. and which is here marked with the same letters.

To the crank-knob *r*, fig 1258, a rod *s*, is attached, which moves or traverses the guide

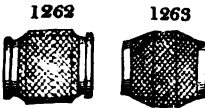


bar belonging to that part of the machine: to each machine one such apparatus is fitted. In figs. 1260. & 1261. another mode of traversing the guide bar is shown, which is generally used for the coarser qualities of silk. Near to one of the middle frames, one of the wheels *f*, in gear with the spur wheel *m*, and the bevel wheel *n*, both revolving on one stud, gives motion also to the wheel *o*, fixed upon a shaft *o'*, at whose other end the

elliptical wheel *v* is fixed, which drives a second elliptical wheel *v'*, in such a way that the larger diameter of the one plays in gear with the smaller diameter of the other; the teeth being so cut as to take into each other in all positions. The crank-piece *d'* is screwed

upon the face of the wheel *v'*, at such a distance from its centre as may be necessary to give the desired length of traverse motion to the guide bar for laying the silk spirally upon the blocks. The purpose of the elliptical wheel is to modify the simple crank motion, which would wind on more silk at the ends of the bobbins than in their middle, and to effect an equality of winding-

on over the whole surface of the blocks. In fig. 1261. the elliptical wheels are shown in front, to illustrate their mode of operating upon each other. Fig. 1262. is a block filled



by the motion of the eccentric, fig. 1258.; and fig. 1263. is a block filled by the elliptical mechanism. As the length of the motions of the bar in the latter construction remains the same during the whole operation, the silk, as it is wound on the blocks, will slide over the edges, and thereby produce the flat ends of the barrel in fig. 1263. The conical ends of the block (fig. 1262.) are produced by the continually shortened motions of the guide bar, as the stud approaches, in its sun-and-planet rotation, nearer to the general centre.

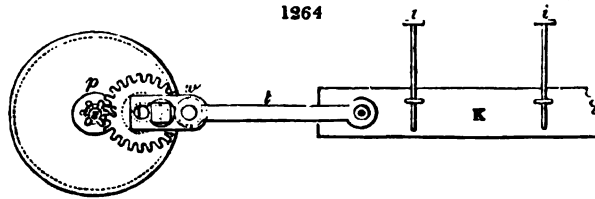
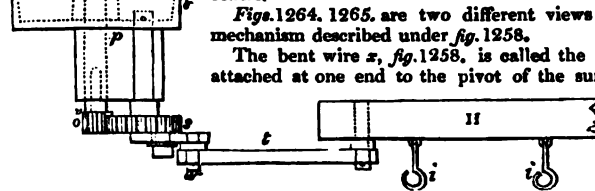


Fig. 1264. 1265. are two different views of the differential mechanism described under fig. 1258.

The bent wire *s*, fig. 1258, is called the guider iron. It is attached at one end to the pivot of the sun-and-planet wheel

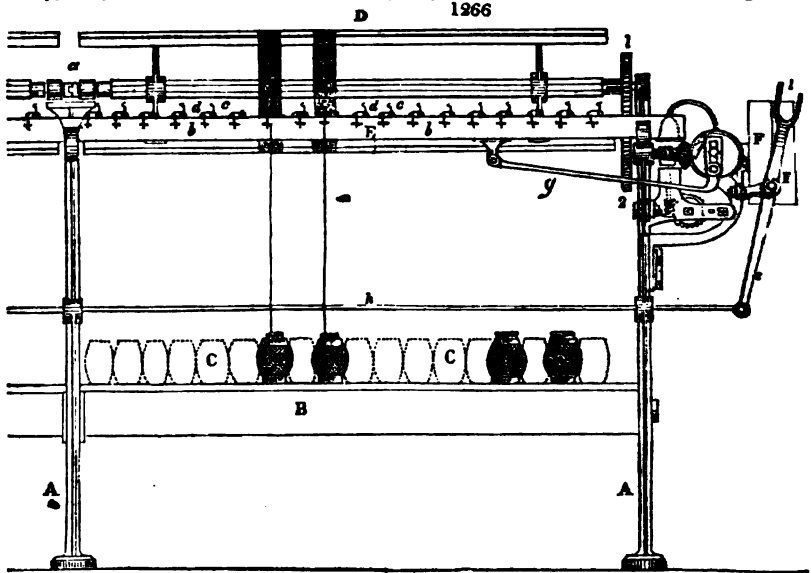


work *t*, *s*, *o*, and at the other to the guide bar *f*, *f*, fig. 1257. The silk threads pass through the guides, as already explained. By the motion communicated to the guide bar (*guider*), the diamond pattern is produced, as shown in fig. 1262.

THE SILK AUTOMATIC REEL.

In this machine, the silk is unwound from the blocks of the throwing-mill, and formed into hanks for the market. The blocks being of a large size, would be productive of much friction, if made to revolve upon skewers thrust through them, and would cause frequent breakage of the silk. They are, therefore, set with their axes upright upon a board, and the silk is drawn from their surface, just as the web is from a cop in the shuttle. On this account the previous winding-on must be executed in a very regular manner; and preferably as represented in *fig. 1262*.

Fig. 1266, is a front view of the reel; little more than one-half of it being shown. *Fig. 1267*, is an end view. Here the steam-pulleys are omitted, for fear of obstructing the



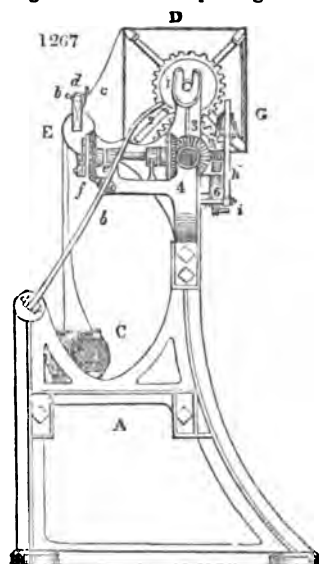
view of the more essential parts. A, A, are the two end framings, connected by mahogany stretchers, which form the table x, for receiving the bobbins c, c, which are sometimes weighted at top with a lump of lead, to prevent their tumbling. D is the reel, consisting of four long laths of wood, which are fixed upon iron frames, attached to an octagonal wooden shaft. The arm which sustains one of these laths is capable of being bent inwards, by loosening a tightening hook, so as to permit the hanks, when finished, to be taken off, as in every common reel.

The machine consists of two equal parts, coupled together at a, to facilitate the removal of the silk from either half of the reel; the attendant first lifting the one part, and then the other. x is the guide bar, which by a traverse motion causes the silk to be wound on in a cross direction. b and c are the wire guides, and d are little levers lying upon the cloth-covered guide bar x. The silk in its way from the block to the reel, passes under these levers, by which it is cleaned from loose fibres.

On the other end of the shaft of the reel, the spur wheel 1 is fixed, which derives motion from wheel 2, attached to the shaft of the steam-pulley r. Upon the same shaft there is a bevel wheel 3, which impels the wheel 4 upon the shaft e; to whose end a plate is attached, to which the crank f is screwed, in such a way as to give the proper length of traverse motion to the guide bar x, connected to that crank or eccentric stud by the jointed rod g. Upon the shaft of the steam-pulleys r, there is a worm or endless screw, to the left of f, *fig. 1267*, which works in a wheel 5, attached to the short upright shaft h (*fig. 1266*). At the end of h, there is another worm, which works in a wheel 6; at whose circumference there is a stud i, which strikes once at every revolution against an arm attached to a bell, seen to the left of a; thus announcing to the reel-tenter that a measured length of silk has been wound upon her reel. e is a rod or handle, by which the fork l, with the strap, may be moved upon the fast or loose pulley, so as to set on or arrest the motion at pleasure.

Throwsters submit their silk to scouring and steaming processes. They soak the

banks, as imported, in lukewarm soap-water in a tub; but the bobbins of the twisted single silk from the spinning mill are enclosed within a wooden chest, and exposed to the opening action of steam for about ten minutes. They are then immersed in a cistern of warm water, from which they are transferred to the doubling frame.



The wages of the work-people in the silk-throwing mills of Italy are about one half of their wages in Manchester; but this difference is much more than counterbalanced by the superior machinery of our mills. In 1832, there was a power equal to 342 horses engaged in the silk-throwing mills of Manchester; and of about 100 in the mills of Derby. The power employed in the other silk mills of England and Scotland has not been recorded.

There is a peculiar kind of silk called *marabout*, containing generally three threads, made from the white Novi raw silk. From its whiteness, it takes the most lively and delicate colours without the discharge of its gum. After being made into tram by the single twist upon the spinning mill, it is reeled into banks, and sent to the dyer without further preparation. After being dyed, the throwster re-winds and re-twists it upon the spinning mill, in order to give it the whipcord hardness which constitutes the peculiar feature of *marabout*. The cost of the raw Novi silk is 19s. 6d. a pound; of throwing it into tram, 2s. 6d.; of dyeing, 2s.; of re-winding and re-twisting, after it has been

dyed, about 5s.; of waste, 2s., or 10 per cent.; the total of which sum is 31s.; being the price of one pound of *marabout* in 1832.

Several pieces of silk were put into my hands, for analysis, after I had visited the St. Katharine's Dock Warehouses, in New Street, Bishopsgate Street, for the purpose of inspecting a large package of Corahs per Colonist. I was convinced, by this inspection, that, notwithstanding the apparent pains bestowed upon the tin plate and teak wood packing-cases, certain fissures existed in them, through which the atmospheric air had found access, and had caused iron-mould spots upon the *gunny* wrapper, from the rusting or oxidizement of the tinned iron.

I commenced my course of analysis upon some of the pieces which were most damaged, as I thought they were most likely to lead me to an exact appreciation of the cause of the mischief; and I pursued the following general train of research:—

1. The piece of silk, measuring from 6 to 7 yards, was freely exposed to the air, then weighed, afterwards dried near a fire, and weighed again, in order to determine its hygrometric property, or its quality of becoming damp by absorbing atmospheric vapour. Many of the pieces absorbed, in this way, from one-tenth to one-eighth of their whole weight; that is, from 1 oz. to 1½ oz. upon 13 oz. This fact is very instructive, and shows that the goods had been dressed in the loom, or imbued subsequently, with some very deliquescent pasty matter.

2. I next subjected the piece to the action of distilled water, at a boiling temperature, till the whole glutinous matter was extracted; five pints of water were employed for this purpose, the fifth being used in rinsing out the residuum. The liquid wrung out from the silk was evaporated first over the fire, but towards the end over a steam bath, till it became a dry extract; which in the damaged pieces was black, like extract of liquorice, but in the sound pieces was brown. In all cases, the extract so obtained absorbed moisture with great avidity. The extract was weighed in its driest state, and the weight noted, which showed the addition made, by the dressing, to the weight of the silk. The piece of silk was occasionally weighed in its cleansed state, when dry, as a check upon the preceding experiment.

3. The dry extract was now subjected to a regular chemical analysis, which was modified according to circumstances, as follows:—100 parts of it were carefully ignited in a platinum capsule; during which a considerable flame and fetid smoke were disengaged. The ashes or incombustible residuum were examined by the action of distilled water, filtration, as also by that of acids, and other chemical tests, whereby the constituents of these ashes were ascertained. In the course of the incineration or calcination of the extract from the several samples, I never observed any sparkling or scintillation; whence I inferred that no nitre had been used in the dressing of the goods, as some persons suggested.

4. Having, in the course of boiling some of the extract from two of the damaged pieces, in a little distilled water, felt a urinous odour, I was induced to institute the following minute course of researches, in order to discover whether the urine of man had been introduced into the dressing paste of the silk webs. I digested a certain portion of the said extract in alcohol, 60 per cent. over proof, which is incapable of dissolving the rice water, or other starchy matter which might be properly applied to the silk in the loom. The alcohol, however, especially when aided by a moderate heat, readily dissolves urea, a substance of a peculiar nature, which is the characteristic constituent of human urine. The alcohol took a yellow tint, and, being after subsidence of the sediment, decanted clear off into a glass retort, and exposed to the gentle heat of a water bath, it distilled over clear into the receiver, and left a residuum in the retort, which possessed the properties of urea. This substance was solid when cold, but melted at a heat of 220° F.; and at a heat of about 245° it decomposed with the production of water and carbonate of ammonia—the well-known products of urea at that temperature. The exhalation of the ammonia was very sensible to the smell, and was made peculiarly manifest by its browning yellow turmeric paper, exposed in a moist state to the fumes, as they issued from the orifice of the glass tube, in which the decomposition was usually effected. I thus obtained perfect evidence that urine had been employed in India in preparing the paste with which a great many of the pieces had been dressed. It is known to every experienced chemist, that one of the most fermentative or putrefactive compositions which can be made, results from the mixture of human urine with starchy or gummy matter, such as rice water; a substance which by the test of iodine water, these Corahs also contained, as I shewed to the gentlemen present, at my visit to the Bonding Warehouse.

5. On incinerating the extract of the Corahs, I obtained, in the residuum, a notable quantity of free alkali; which, by the test of chloride of platinum, proved to be potassa. But, as the extract itself was neutral to the tests of litmus and turmeric paper, I was consequently led to infer, that the said extract contained some vegetable acid, probably produced by the fermentation of the weaver's dressing, in the hot climate of Hindostan. I, accordingly, examined the nature of this acid, by distilling a portion of the extract along with some very dilute sulphuric acid, and obtained, in the receiver, a notable quantity of the volatilised acid condensed. This acid might be the acetic (vinegar), the result of fermentation, or it might be the formic or acid of ants, the result of the action of sulphuric acid upon starchy matter. To decide this point, I saturated the said distilled acid with magnesia, and obtained on evaporation the characteristic gummy mass of acetate of magnesia, soluble in alcohol, but none of the crystals of formiate of magnesia insoluble in alcohol. From the quantity of alkali (potassa) which I obtained from the incineration of the extract of one piece of the damaged silk, and which amounted to six grains at least, I was convinced that wood ashes had been added, in India, to the mixture of sour rice water and urine, which would therefore constitute a compound remarkably hygrometric, and well qualified to keep the warp of the web damp, even in that arid atmosphere, during the time that the Tanty or weaver was working upon it. The acetate of potassa, present in the said Corahs, is one of the most deliquescent salts known to the chemist: and, when mixed with fermented urine, forms a most active hygrometric dressing,—one, likewise, which will readily generate mildew upon woven goods, with the aid of heat and the smallest portion of atmospheric oxygen. By the above-mentioned fermentative action, the carbon, which is one of the chemical constituents of the rice or starchy matter, had been eliminated, so as to occasion the dark stains upon the silk, and the blackness of the extract taken out of it by distilled water.

6. That the dressing applied to the webs is not simply a decoction of rice, becomes very manifest, by comparing the incinerated residuum of rice with the incinerated residuum of the extract of the said Corahs. I find that 100 grains of rice, incinerated in a platinum capsule, leave only about one fifth of a grain, or 1 in 500 of incombustible matter, which is chiefly siliceous sand; whereas, when 100 grains of an average extract of several of these Corahs were similarly incinerated, they left fully 17 parts of incombustible matter. This consisted chiefly of alumina or earth of clay, with silica, potassa, and a little common or culinary salt. (Has the clay been added, as is done in Manchester, to give apparent substance to the thin silk web?)

From the above elaborate course of experiments, which occupied me almost constantly during a period of four weeks, I was fully warranted to conclude that the damage of the said goods had been occasioned by the vile dressing which had been put into them in India; which, as I have said, under the influence of heat and air, had caused them to become more or less mildewed, in proportion to their original dampness when packed at Calcutta, and to the accidental ingress of atmospheric air into the cases during the voyage from Calcutta to London.

The following is the list of Corahs which I chemically examined:—

1 and 2, per Colonist, from Calcutta, 2 pieces, sound.—These two pieces had been dressed with a sweet viscid matter, like jaggery or goor (molassy sugar), mixed with the rice water. This extract contained no urine, but emitted a smell of caramel or burned sugar, when ignited. It amounted to 270 grains in the one, and 370 in the other.

3, ditto, 1 piece, mildewed, 1st degree.—This piece had been dressed like No 5, and contained no trace of urine. It afforded 400 grains of a most deliquescent sweetish glutinous matter.

4, ditto, 1 piece, mildewed, 1st degree, as No. 3.

5, ditto, 1 piece, mildewed, 3d degree.—This piece contained no trace of urine, but it afforded 210 grains of a light brown extract, being rice water, mixed with something like jaggery.

6, ditto, 1 piece, 3d degree, mildewed.—This piece afforded evidence of urine in it, by test of carbonate of ammonia. The extract amounted to 320 grains.

8, ditto, 2 pieces, damaged in the 3d degree.—The total weight of one of these pieces, after exposure to air, was 4610 grains, and it lost 440 grains by drying. The total weight of the other was 4950 grains, and it lost 320 grains by drying. The weight of extract was, in one piece, 210 grains; and both pieces contained abundant traces of urine, as well as of potash. These constituents, along with the rice water, accounted sufficiently for the great damage of these two pieces by mildew.

10, ditto, 2 pieces, sound.—These contained no urea. Each afforded from 300 to 500 grains, of a light brown vegetable extract.

12, ditto, 2 pieces.—The extract in the one amounted to 222 grains, and in the other to 330. Both contained urea, and had therefore, been imbued with urine.

14, ditto, 2 pieces, mildewed, 3d degree.—There was no urea in the extracts from these two pieces; but they afforded, the one 300 grains of extract, and the other 750. But this extract was a saccharine molassy matter, impossible to dry over a steam heat. The same quantity as the last, if dried by stronger means, would have weighed probably 600 grains. Its extraordinary deliquescence kept the pieces very moist, and thereby caused the mildewing of them. With the saccharine matter, four per cent. of culinary salt was mixed in one of these extracts.

16, ditto, 2 pieces, 3d degree of mildew.—The extract, about 200 grains, contained abundant evidence of urea, and, consequently, of urine.

18, ditto, 2 pieces, sound.—Both these contained some traces of urea; but the one yielded only 102 grains of extract, and the other 370 grains. They must have been well screened from the air to have resisted the action of the urine.

20, ditto, 2 pieces, damaged, 1st degree.—No urea. The extract of the one was 320 grains; of the other piece 380; and it had a light brown colour, being a saccharine mucilage.

22, ditto, 2 pieces, 3d degree mildew.—200 grains of extract in the one, and 210 in the other: they contained urea.

24, 2 pieces, 3d degree of mildew.—310 grains of extract in the one, and 180 grains in the other. Both were impregnated with urea, and consequently with urine.

Having in the preceding report demonstrated, by the clearest processes of chemical research, that the above mildewed Corahs had been damaged by the fermentative decomposition of the dressing paste with which they had been so abundantly impregnated, I would recommend the importers of such goods to cause the whole of the dressing to be washed out of them, and the pieces to be thoroughly dried before being packed up. I believe that clean silk may be kept and transported, even in the most humid atmosphere, without undergoing any change, if it be not imbued with fermentative paste.

I examined eight other pieces of a different mark, imported by another mercantile house, per Colonist, and they afforded results similar to the above.

The beautiful and artistic silk trophy, occupying the entrance to the Western Nave of the Exhibition, did not fail to attract notice. This trophy consisted of an elegant arrangement of rich tissues, brocades, damasks, and other furniture, silks, the whole of which had been manufactured by Messrs. Keith & Co., and was surmounted by a silken banner. A variety of rich and costly productions of the Spitalfields loom were exhibited in the Galleries.

The colours and textures of these fabrics were of great brilliancy and finish. An interesting collection of specimens of the raw and manufactured material was also exhibited. Specimens of silk-plush for various purposes and in imitation of furs were likewise found among these articles. The ribands of Coventry have acquired a universal reputation; and this characteristic manufacture was well represented in the number and variety of the articles exhibited. The application of steam power as a substitute for hand-weaving in this manufacture is making rapid progress, and some of its results were apparent.

At present the United Kingdom draws its supply of the raw material for manufacture principally from the East Indies; and France, Italy, Turkey, and China, also

supply a considerable amount. Ten years since, the annual imports for home consumption amounted to the large sum of 4,734,755 lbs. When it is remembered that all this vast quantity of textile fibre is the result of the industry of larvae, an idea may be gained of the importance of things seemingly insignificant.

Manchester exhibited Gros de Naples as good and as cheap as that of Lyons; and the establishment of our Schools of Design bids fair to secure our superiority in the taste and beauty of our patterns.

Silk (Switzerland). There are some silk-stuff factories in the Canton of Bâle: but the staple trade of this town lies in the manufacture of silk ribbons. In this and the neighbouring canton of Bâle-Champagne there are about 4,000 looms, which give employment to 16,000 workmen as weavers, dyers, &c. Manual labour is extremely cheap, enabling the manufacturer to sell at a very low rate. The principal part of the manufacturers of this canton employ their own capital, and have not to surmount those difficulties and disadvantages inseparable from the employment of borrowed capital. The medium annual produce of the manufactures of Bâle is about 20,000,000 of francs, part of which is imported into most European countries, America and the Colonies. The principal articles of manufacture are plain taffeta, ribbons, plain satin and figured ribbons: in all these articles, Bâle maintains an incontestable superiority.

The most cordial understanding exists between employers and employed, and the strikes and coalitions so injurious to other manufacturing countries are unknown in Switzerland. There is no fixed tariff for the price of manual labour.

The silk trade in this country has grown and prospered without the aid of protective duties, and it is a remarkable fact that the difficulties occasioned by the high prohibitive customs, instead of being prejudicial, have been of advantage, by increasing the active genius and emulation of the manufacturers, and inducing them to seek more distant and more favourable outlets for their goods. The morality, activity and commercial knowledge of the Swiss may be considered the basis of their success in this most important branch of trade.

Silk, (Austria). Of all the states of Europe, the Austrian monarchy possesses the most abundant supply of silk. The production of silk is conducted on the most important scale in the Lombardo-Venetian kingdom; next in order of importance comes the Tyrol: the same business is also carried on in the military frontier, Görz and Gradiška, and also in Istria and Trieste, in Dalmatia and south of Hungary. Trials have likewise been made in Lower Austria, Bohemia, and Carniola. The productions of cocoons amount on an average annually

| | | | | | | |
|------------------------|---|---|---|---|---|-----------------|
| In Lombardy | - | - | - | - | - | to 250,000 cwt. |
| The province of Venice | - | - | - | - | - | 900,000 |
| The Tyrol | - | - | - | - | - | 28,000 |
| The other provinces | - | - | - | - | - | 12,000 |

Total 490,000 cwt.

Or, in round numbers, 500,000 cwt.

The cocoons are prepared at the reeling establishment into raw silk. From the result of inquiries, it would appear that Lombardy comprises 3,060 reeling establishments, which employ 79,500 workpeople, without taking into calculation the smaller establishments, which are not included in this enumeration. The entire production amounts to 2,512,000 Vienna lbs.; and since 12 lbs. of cocoons yield 1 lb. of raw silk there are required for this aggregate of raw silk 300,400 cwt. of cocoons. The quantity of cocoons required in excess of the quantity produced, an excess of nearly 50,000 cwt., is covered by the production of the Venetian provinces, chiefly by that of Verona.

Within the province of Venice, the reeling establishments are pretty numerous, but of less extent. The nearest approximation in reference to this matter is obtained by taking the extent of the production at one-half of that in Lombardy. The remainder of the cocoons produced in the province undergo further preparation in Lombardy, and partly in the Tyrol also, whilst a portion of those obtained in Görz and Gradiška, as well as in Istria, are prepared in Venetian reeling establishments.

The number and the performance of the reeling machines in the Tyrol are accurately known. In the year 1848 South Tyrol contained 559 of such reeling establishments. These employed 13,000 hands, and turned out 265,700 lbs. of raw silk from 31,900 Vienna cwt. of cocoons. The supply of cocoons required beyond that furnished by the production of the country was drawn from the Venetian provinces.

The reeling establishments in the remaining provinces produce conjointly from 10,000 cwt. of cocoons 75,000 Vienna lbs. of raw silk.

The whole production of raw silk obtained in the Austrian monarchy is about 4,108,700, and the waste about 716,400 lbs. The number of working hands employed in the reeling establishments is not less than 160,000 (or if their term of occupation be

reduced to 270 days in the year, 30,000 only). Besides the products already enumerated about 900 cwt. of cocoons are annually imported into Lombardy, principally from Switzerland, and the neighbouring Italian States, and are prepared in the Lombardy reeling establishments. The quantity of silk produced is thus increased to an aggregate of 4,116,200 lbs.

The raw silk undergoes further preparation in the throwing mills, but the whole mass of the production is not thus worked up within the monarchy, for the exports of raw silk are found considerably to exceed the imports. On an average of the five years 1843 to 1847, the annual imports were 110,000 Vienna lbs. of raw silk (through Venice, Switzerland, and the adjacent Italian States), whilst 70,000 lbs. of this commodity were exported, for the most part to Switzerland, the adjacent states of Italy, and Southern Germany. Hence it results that a balance of raw silk, amounting to 589,000 lbs., have been taken off by foreign consumption, and that the other 3,518,800 Vienna lbs. are retained by the states of the monarchy, and more than two-thirds thereof are worked up in Lombardy. In 1817, that province reckoned 500 throwing mills, with 1,239,000 spindles; and of these 702,100 were for spinning, and 507,209 for twisting. In the throwing mills themselves, 12,000 hands were employed, (namely, 4,400 men, 5,500 women, and 2,100 children,) and, moreover, there were occupied 31,800 female winders. The production yielded was 989,000 Vienna lbs. of tram, and 1,189,700 lbs. of thrown silk; for this aggregate of production 2,256,200 lbs. of raw silk were used. The floss silk was to the weight of 76,000 lbs.

The working of the throwing mills of Venice produced, in proportion to those of Lombardy, almost similar results to those above indicated in reference to the reeling establishments; only the production of tram greatly preponderates. The number of persons employed in the throwing mills, both within and without doors, were 20,000; their production was above 960,000 Vienna lbs., and the consumption of raw silk by the conversion into this quantity was 1,009,000 lbs., giving waste (floss) to the amount of 47,400 lbs.

There are at present in the Tyrol 55 throwing mills, with 125,047 spindles; 85,583 of which latter are for spinning, and 39,464 for twisting. In these mills 500 men and 1,200 women and children are employed. The production there, including that of the smaller throwing mills, which give occupation to 500 workmen, amount to 220,400 Vienna lbs. of thrown silk, for which 231,400 Vienna lbs. of raw silk have to be worked up.

Of the remainder of the raw silk (23,200 lbs.) about 14,000 lbs. are distributed through the other southern provinces, and the remaining 9,200 lbs. appropriated to other purposes.

Thus we find a resulting total of production equal to 3,374,000 Vienna lbs. of thrown silk.

Silk in the Exhibition.—*Simpson, Miles, 5, Aldermanbury Postern, 4, Milk Street, Manchester, Leek, and Derby.*—*Manufacturer.* Specimens of the leading classes of raw silks, from France, Italy, China, Bengal, and Turkey, selected by Messrs. Durant & Co.

Sewing, netting-silk, and twist, intended to show the varieties of quality, their richness and beauty of colour.

Sewing, netting silk and twist.

Raven and jet sewings, in weight and form as sold in the market, of four qualities.

Crochet and Mohair silks, exhibited for quality and price.

Shoe mercery, consisting of silk and union galloons, doublers, braids, and round silk laces, yellow and black borders, &c. Specimens of union cord.

In 1849, the enormous quantity of 6,269,179 lbs. of silk in its several conditions of raw, waste, and thrown, was imported into this country. The manufacture employs upwards of 33,000 individuals, and is carried on in nearly 300 silk factories. The sum annually expended on silk goods in England is taken at considerably upwards of fifteen millions annually.

In the following Table are included

| | 1830. | | 1851. | |
|--------------------------------------|------------------|--------------------|------------------|--------------------|
| | lbs. | lbs. | lbs. | lbs. |
| Imports to Liverpool of - - - | China 121,278 | Bengal 34,650 | China 166,770 | Bengal 6,450 |
| Stocks at Liverpool, 31st December - | Do. 5,304 | Do. 1,950 | Do. 2,550 | Do. none. |
| Also, exports as "Consumption" - | Raw Silk 800,786 | Thrown Silk 56,578 | Raw Silk 482,348 | Thrown Silk 66,680 |

The Imports warehoused in December were—

| | | | | | |
|----------------|-------------|--------------|-------------|----------------|----------|
| China - - - | 1,377 bales | Bengal - - - | 1,262 bales | Chinese Thrown | 90 bales |
| Italian Raw - | 904 | Brutia - - - | 86 | Persian - - - | 358 |
| Italian Thrown | 107 | Greek - - - | 5 | Canton - - - | 1414 |

Of the above 237 bales China were at the port of Liverpool.

| Description. | Imports | | Extreme Prices | | | | | | Consumption | | Stock | | Prices | | | | | |
|--------------|-----------|-----------|----------------|----|--------------|----|-------|----|-------------|---------|-----------------|-----------------|----------------|-----------|-----|----------------|-----|-----|
| | 1850. | 1851. | during 1850. | | during 1851. | | 1850. | | 1851. | | 31st Dec. 1850. | 31st Dec. 1851. | 1st Jan. 1851. | | | 1st Jan. 1852. | | |
| CHINA— | lbs. | lbs. | l. | d. | s. | d. | l. | d. | s. | d. | lbs. | lbs. | l. | s. | d. | l. | s. | d. |
| Tartan | 1,721,988 | 1,279,488 | 14 | 6 | 0 | 22 | 0 | 14 | 6 | 0 | 22 | 0 | 1,455,500 | 1,258,991 | 681 | 156 | 721 | 650 |
| Tussan | 511,876 | 627,810 | 9 | 6 | 17 | 6 | 10 | 0 | 17 | 6 | 423,198 | 697,782 | 597 | 731 | 237 | 763 | 12 | 0 |
| Cardon | 119,169 | 367,719 | 8 | 6 | 13 | 9 | 7 | 0 | 14 | 0 | 31,722 | 282,403 | 79,068 | 165 | 286 | 7 | 0 | 15 |
| China Chew | 11,839 | 39,038 | 5 | 0 | 8 | 0 | 4 | 6 | 7 | 0 | 27,248 | 40,606 | 11,424 | 2,836 | 5 | 6 | 8 | 0 |
| Thrown | 56,244 | 56,000 | 16 | 6 | 19 | 6 | 13 | 6 | 18 | 6 | 31,798 | 67,769 | 37,856 | 26,696 | 18 | 0 | 18 | 6 |
| BENGAL | 1,510,550 | 1,255,870 | 5 | 6 | 19 | 6 | 3 | 0 | 19 | 0 | 1,255,056 | 1,252,510 | 1,000,550 | 981 | 88 | 3 | 6 | 19 |
| BRITISH | 442,470 | 186,690 | 11 | 0 | 18 | 0 | 11 | 0 | 18 | 0 | 394,040 | 276,000 | 113,060 | 24,200 | 13 | 0 | 10 | 0 |
| PERSIAN | 519,423 | 229,240 | 8 | 0 | 11 | 0 | 8 | 6 | 11 | 0 | 253,656 | 282,500 | 78,080 | 15,150 | 9 | 0 | 10 | 6 |
| GREEK | 27,150 | 13,200 | 13 | 0 | 12 | 0 | 21 | 0 | 21 | 0 | 23,100 | 15,050 | 4,000 | 4,050 | 14 | 0 | 21 | 6 |
| SYRIAN | 7,110 | 10,850 | 20 | 9 | 26 | 0 | 18 | 9 | 22 | 0 | 7,140 | 10,850 | none | none | 0 | 0 | 0 | 21 |
| ITALIAN— | | | | | | | | | | | | | | | | | | |
| Raw | 629,500 | 562,510 | 15 | 0 | 28 | 6 | 17 | 0 | 28 | 6 | 699,480 | 637,150 | 306,820 | 252,000 | 19 | 0 | 28 | 6 |
| Thrown | 410,800 | 563,080 | 18 | 6 | 51 | 0 | 19 | 0 | 50 | 6 | 542,300 | 496,580 | 159,500 | 116,000 | 19 | 6 | 50 | 6 |
| Total | 5,585,729 | 4,959,915 | — | — | — | — | — | — | — | 280,226 | 5,213,595 | 2,780,908 | 2,597,250 | — | — | — | — | — |

•• Average net weight of a bale of Bengal 150 lbs.; China Raw 102 lbs.; Chinese Thrown 112 lbs.; British 210 lbs.; Italian 290 lbs.; and a ballot of Persian 75 lbs.

* 1st January 1851—The Stock of China of 1,118,158 lbs. is estimated at 779,172 lbs. sold, and 338,986 lbs. unsold do. 1852 do. 1,155,630 lbs. 934,748 lbs. 198,882 lbs.

In the Import of British are included 12,260 lb. of a superior sort, from 19s. 6d. to 27s. 6d. Unsold 5,460 lbs. do. China Chew are included 6,480 of Kohat silk do. none. do. do. 2,500 of China Tussan 6 0 — do. none.

An ESTIMATE of the Annual Quantities of Silk produced or exported from the several Countries in the World, exhibiting also the Countries to which exported.

Note. — These estimates exclude the silk manufactured in Italy.

| Countries whence exported. | Quantities. | Countries to which exported. | Quantities. |
|--|--------------------------------|------------------------------|-------------|
| Italy exports | 34,000 bales of 225 small lbs. | | Bales. |
| France produces | 10,500 " | } England - | 28,000 |
| India and Bengal export | 9,500 " | | } France - |
| Persia | 7,500 " | Prussia - | 7,600 |
| China | 4,000 " | Russia - | 6,400 |
| Asia Minor | 3,500 " | Austria and | 5,000 |
| Levant, Turkey, and Archipelago export | 3,500 " | Germany | |
| Spain | 1,500 " | Switzerland | 5,000 |
| Total | 74,000 bales. | Total | 74,000 |

State of the Warehouses in London, ending December 31, 1850 and 1851.

| | Sold Stock. | | Unsold Stock. | | Delivered in Dec. | |
|----------------|-------------|--------|---------------|--------|-------------------|--------|
| | 1850. | 1851. | 1850. | 1851. | 1850. | 1851. |
| | Bales. | Bales. | Bales. | Bales. | Bales. | Bales. |
| Bengal | 4,286 | 3,067 | 2,370 | 3,715 | 683 | 608 |
| " Liverpool | — | — | 13 | — | — | — |
| China | 7,376 | 7,698 | 3,157 | 1,675 | 1,842 | 1,752 |
| " Liverpool | — | — | 25 | — | — | 92 |
| Canton | — | 1,134 | — | 232 | — | 185 |
| " Liverpool | — | — | — | — | — | — |
| Chinese Thrown | 234 | 233 | 104 | — | 32 | 138 |
| " Liverpool | — | — | — | — | — | — |
| Total | 11,896 | 12,157 | 5,696 | 5,622 | 2,257 | 2,775 |

* Included in China, but the quantity very small.

Average Monthly Deliveries from the Warehouses in London, from 1st Jan. to 31st Dec. in the Years 1849, 1850, and 1851 (including Liverpool).

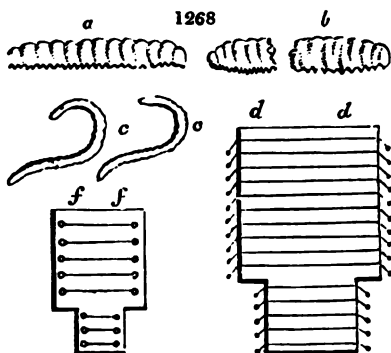
| | 1849. | 1850. | 1851. |
|------------------|----------------|---------------------|---------------------|
| | Bengal - - - - | 715 Bales per Month | 780 Bales per Month |
| China - - - - | 72 " " " | 1608 " " " | 1784 " " " |
| China Thrown - - | 45 " " " | 31 " " " | 50 " " " |

The following is an

Account of the Exports of SILK of British Produce and Manufacture.

| | Quantities. | | Declared Value. | |
|---|-------------|---------|-----------------|-----------|
| | 1850. | 1851. | 1850. | 1850. |
| Manufactures of silk only : — | | | £ | £ |
| Stuffs, handkerchiefs, and ribbons - - lbs. | 419,366 | 436,301 | 487,450 | 534,418 |
| Stockings - - - doz. pair | 12,269 | 15,986 | 20,261 | 26,557 |
| All other descriptions - value | — | — | 174,879 | 194,987 |
| Of silk mixed with other materials : — | | | | |
| Stuffs, handkerchiefs, and ribbons - - lbs. | 766,358 | 748,694 | 332,140 | 347,386 |
| Stockings - - - doz. pair | 4,143 | 4,971 | 3,153 | 4,651 |
| All other descriptions - value | — | — | 23,102 | 26,432 |
| Total - - - - | - | - | 1,040,985 | 1,134,931 |
| Silk thrown - - - lbs. | 69,993 | 72,460 | 53,273 | 57,803 |
| Silk twist and yarn - lbs. | 474,349 | 389,901 | 161,383 | 138,635 |
| Total - - - - | - | - | 1,255,641 | 1,331,369 |

SILKWORM GUT, for angling, is made as follows:—Select a number of the best and largest silkworms, just when they are beginning to spin; which is known by their refusing to eat, and having a fine silk thread hanging from their mouths. Immerse them in strong vinegar, and cover them closely for twelve hours, if the weather be warm, but two or three hours longer, if it be cool. When taken out, and



pulled asunder, two transparent guts will be observed, of a yellow green colour, as thick as a small straw, bent double. The rest of the entrails resembles boiled spinage, and therefore can occasion no mistake as to the silk-gut. If this be soft, or break upon

stretching it, it is a proof that the worm has not been long enough under the influence of the vinegar. When the gut is fit to draw out, the one end of it is to be dipped into the vinegar, and the other end is to be stretched gently to the proper length. When thus drawn out, it must be kept extended on a thin piece of board, by putting its extremities into slits in the end of the wood, or fastening them to pins, and then exposed in the sun to dry. Thus genuine silk-gut is made in Spain. From the manner in which it is dried, the ends are always more or less compressed or attenuated.* *Fig.* 1268. *a*, is the silkworm; *b*, the worm torn asunder; *c*, *e*, the guts; *d*, *d*, a board slit at the ends, with the gut to dry; *f*, *f*, boards with wooden pegs, for the same purpose.

SILVER (*Argent*, Fr.; *Silber*, Germ.) was formerly called a *perfect* metal, because heat alone revived its oxide, and because it could pass unchanged through fiery trials, which apparently destroyed most other metals. The distinctions, perfect, imperfect, and noble, are now justly rejected. The bodies of this class are all equal in metallic nature, each being endowed merely with different relations to other forms of matter, which serve to characterise it, and to give it a peculiar value.

When pure and planished, silver is the brightest of the metals. Its specific gravity in the ingot is 10·47; but, when condensed under the hammer or in the coining press, it becomes 10·6. It melts at a bright red heat, a temperature estimated by some as equal to 1280° Fahr., and by others to 22° Wedgewood. It is exceedingly malleable and ductile; affording leaves not more than $\frac{1}{100000}$ of an inch thick, and wire far finer than a human hair.

By Sickingen's experiments, its tenacity is, to that of gold and platinum, as the numbers 19, 15, and 26½; so that it has an intermediate strength between these two metals. Pure atmospheric air does not affect silver, but that of houses impregnated with sulphuretted hydrogen, soon tarnishes it with a film of brown sulphuret. It is distinguished chemically from gold and platinum by its ready solubility in nitric acid, and from almost all other metals, by its saline solutions affording a curdy precipitate with a most minute quantity of sea salt or any soluble chloride.

Silver occurs under many forms in nature:—

1. *Native silver*, possesses the greater part of the above properties; yet, on account of its being more or less alloyed with other metals, it differs a little in malleability, lustre, density, &c. It sometimes occurs crystallized in wedge-form octahedrons, in cubes, and cubo-octahedrons. At other times it is found in dendritic shapes, or arborescences, resulting from minute crystals implanted upon each other. But more usually it presents itself in small grains without determinable form, or in amorphous masses of various magnitude.

The *gangues* (mineral matrices) of native silver are so numerous, that it may be said to occur in all kinds of rock. At one time it appears as if filtered into their fissures, at another as having vegetated on their surface, and at a third, as if impasted in their substance. Such varieties are met with principally in the mines of Peru.

The native metal is found in almost all the silver mines now worked; but especially in that of Kongsberg in Norway, in carbonate and fluete of lime, &c.; at Soblangenberg in Siberia, in a sulphate of barytes; at Allémont, in a ferruginous clay, &c. In the article *MINES*, I have mentioned several large masses of native silver that have been discovered in various localities.

The metals most usually associated with silver in the native alloy, are gold, copper, arsenic, and iron. At Andreasberg and Guadalcanal it is alloyed with about 5 per cent. of arsenic. The auriferous native silver is the rarest; it has a brass-yellow colour.

2. *Antimonial silver*.—This rare ore is yellowish-blue; destitute of malleability; even very brittle; spec. grav. 9·5. It melts before the blowpipe, and affords white fumes of oxide of antimony: being readily distinguished from arsenical iron and arsenical cobalt by its lamellar fracture. It consists of from 76 to 84 of silver, and from 24 to 16 of antimony.

3. *Mixed antimonial silver*.—At the blowpipe it emits a strong garlic smell. Its constituents are, silver 16, iron 44, arsenic 35, antimony 4. It occurs at Andreasberg.

4. *Sulphuret of silver*.—This is an opaque substance, of a dark-gray or leaden hue; slightly malleable, and easily cut with a knife, when it betrays a metallic lustre. The silver is easily separated by the blowpipe. It consists of, 13 of sulphur to 89 of silver, by experiment; 13 to 87 are the theoretic proportions. Its spec. grav. is 6·9. It occurs crystallized in most silver mines, but especially in those of Freyberg, Joachimsthal in Bohemia, Schemnitz in Hungary, and Mexico.

5. *Red sulphuret of silver; silver glance*.—Its spec. grav. is 5·7. It contains from 84 to 86 of silver.

6. *Sulphuretted silver with bismuth*.—Its constituents are, lead 35, bismuth 27, silver 15, sulphur 16, with a little iron and copper. It is rare.

* Nobb's Art of Trolling.

7. *Antimoniated sulphuret of silver*, the red silver of many mineralogists, is an ore remarkable for its lustre, colour, and the variety of its forms. It is friable, easily scraped by the knife, and affords a powder of a lively crimson red. Its colour in mass is brilliant red, dark red, or even metallic reddish-black. It crystallizes in a variety of forms. Its constituents are,—silver from 56 to 62; antimony from 16 to 20; sulphur from 11 to 14; and oxygen from 8 to 10. The antimony being in the state of a purple oxide in this ore is reckoned to be its colouring principle. It is found in almost all silver mines; but principally in those of Freyberg, Saint-Marie-aux-Mines and Guadalcanal.

8. *Black sulphuret of silver*, is blackish, brittle, cellular, affording globules of silver at the blowpipe. It is found only in certain mines, at Allémont, Freyberg; more abundantly in the silver mines of Peru and Mexico. The Spaniards call it *negrillo*.

9. *Chloride of silver or horn silver*.—In consequence of its semi-transparent aspect, its yellowish or greenish colour, and such softness that it may be cut with the nail, this ore has been compared to horn, and may be easily recognised. It melts at the flame of a candle, and may be reduced when heated along with iron or black flux, which are distinctive characters. It is seldom crystallized; but occurs chiefly in irregular forms, sometimes covering the native silver as with a thick crust, as in Peru and Mexico. Its density is only 4.74.

Chloride of silver sometimes contains 60 or 70 per cent. of clay; and is then called butter-milk ore by the German miners. The blowpipe causes globules of silver to sweat out of it. This ore is rather rare. It occurs in the mines of Potosi, of Annaberg, Freyberg, Allémont, Schlangenberg, in Siberia, &c.

Mix 1 part of it, with 1 of powdered charcoal, and 2 of nitre, and project the mixture rapidly in small successive portions into a red-hot crucible, and maintain the fused metal in ignition for a quarter of an hour.

10. *Carbonate of silver*, a species little known, has been found hitherto only in the mine of S. Wenceslas, near Wolfache.

TABLE of the Quantities of SILVER brought into the market every year, on an average, from 1790 to 1802.

| Old Continent. | Lbs. Avoird. | New Continent. | Lbs. Avoird. |
|----------------------------|--------------|----------------------------|--------------|
| ASIA. | | | |
| Siberia - - - | 38,500 | Central America - - | 1,320,000 |
| EUROPE. | | | |
| Hungary - - - | 44,000 | South America - - | 605,000 |
| Austrian States - - | 11,000 | | |
| Hartz and Hessia - - | 11,000 | | |
| Saxony - - - | 22,000 | | |
| Norway - - - | 22,000 | | |
| Sweden - - - | 11,000 | | |
| France - - - | | | |
| Spain - - - | | | |
| Total of the Old Continent | 159,500 | Total of the New Continent | 1,925,000 |

Thus the New Continent furnished twelve times more silver than the Old. For more detailed statistics of silver, see the end of the article.

The following is Mr. Ward's description of the treatment of silver ores in Mexico:—

"After returning from San Augustin," says he, "I passed the whole of the afternoon at the *hacienda* (metallurgic works) of Salgado, in which the ores of the Valenciana mine are reduced. The *hacienda*, of which a representation is given below *fig.* 1001. contain forty-two crushing-mills, called *arrastres*, and thirty-six stampers. The ore, on being extracted from the mine, is placed in the hands of the *pepenadores*, men and women, who break all the larger pieces with hammers, and after rejecting those in which no metallic particles are contained, divide the rest into three classes" (inferior, middling, and rich). "These are submitted to the action of the *morteros* (stamps), one of which, of eight stampers, is capable of reducing to powder ten *cargas* of ore (each of 350 lbs.) in twenty-four hours. This powder not being thought sufficiently fine for the quicksilver to act upon with proper effect, it is transferred from the *morteros* to the *arrastres* (crushing-mills, see wood-cut), in which water is used. Each of these reduces to a fine impalpable metalliferous mud, six quintals (600 lbs.) of powder in

24 hours. At Guanajuato, where water-power cannot be obtained, the *arrastres* are worked by mules (see *fig.* 1269.), which are kept constantly in motion at a slow pace, and are changed every 6 hours. The grinding-stones, as well as the sides and bottom of the mill itself, are composed of granite; four blocks of which revolve in each crushing-mill, attached to cross-bars of wood. This part of the operation is thought of great importance, for it is upon the perfection of the grinding that the saving of the quicksilver is supposed in a great measure to depend, in the subsequent amalgamation. The grinding is performed usually in a covered shed or gallery which in a large *hacienda*, like Salgado, from the number of *arrastres* at work at the same time, is necessarily of considerable extent."

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The Gallera of the Hacienda of Salgado

Fig. 1270. represents the rude grinding apparatus used at the *lavaderos*, or gold washings, in Chile. The streamlet of water conveyed to the hut of the gold washer, is received upon



1270

a large rude stone, whose flat surface has been hollowed out into a shallow basin, and in the same manner into 3 or 4 others in succession; the auriferous particles are thus allowed to deposit themselves in these receptacles, while the lighter earthy atoms, still suspended, are carried off by the

running water. The gold thus collected is mixed with a quantity of ferruginous black sand and stony matter, which requires the process of trituration, effected by the very rude and simple *trápiche* shown in the figure; consisting of two stones, the under one being about three feet in diameter, and slightly concave. The upper stone is a large spherical boulder of syenitic granite, about two feet in diameter, having on its upper part two iron plugs fixed oppositely, to which is secured, by lashings of hide, a transverse horizontal pole of *canela* (cinnamon) wood, about 10 feet long; two men seated on the extremities of this lever, work it up and down alternately, so as to give to the stone a rolling motion, which is sufficient to crush and grind the materials placed beneath it. The washings thus ground, are subjected to the action of running water, upon inclined planes formed of skins, by which process the siliceous particles are carried off, while a portion of the ferruginous matter, mixed with the heavier grains of gold, is extracted by a loadstone; it is again washed, till nothing but pure gold-dust remain. The whole process is managed with much dexterity; and if there were much gold to be separated, it

would afford very profitable employment; but generally the small quantity collected is sufficient only to afford subsistence to a few miserable families.

The *tropiche*, *ingenio*, or mill, for grinding the ores of silver, is a very simple piece of mechanism. A place is chosen where a small current of water, whose section will present a surface of six inches diameter, can be brought to a spot where it can fall perpendicularly ten or twelve feet; at this place a well is built of this depth, about 6 feet in diameter; in its centre is fixed an upright shaft, upon a central brass pin; it is confined above by a wooden collar. A little above its foot, the shaft has a small wheel affixed to it, round which are fixed a number of radiating spokes, shaped at the end somewhat like cups, and forming altogether a horizontal wheel, four feet in diameter. Upon the slanting edges of the cups, the water is made to strike with the force it has acquired in falling down a nearly perpendicular trough, scooped out of the solid trunk of a tree. This impression makes the wheel turn with a quick rotatory motion. The upright axis rises about 6 feet above the top of the well, at about half which height is inserted a small horizontal arm, four feet long, which serves as an axle to a ponderous mill-stone of granite, of from four to six feet diameter, which is made to roll on its edge in a circular trough, sometimes made of the same material, and sometimes of hard wood.

The weight of this quickly rolling stone effects the pulverization of the ore. In some cases, it is taken out in the dry state, and sifted; but more generally the separation of the finely ground particles is accomplished by the action of running water. For this purpose a small stream is made to trickle into the circular trough, by which the pounded ore is worked up into a muddy consistence, and the finer particles flow off with the excess of water, through a notch cut in the margin of the trough. This fine matter is received in little pools, where the pounded ore is left to settle; and the clear water

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being run off, the powder is removed from the bottom, and carried to the place of amalgamation.

The *ingenios*, or stamping-mills, are driven by a small breast water-wheel, of five feet diameter, and one foot broad. Fig. 1271. will give a sufficient idea of their construction. The long horizontal shaft, fixed on the axis of the wheel, is furnished with 5 or 6 cams placed at different situations round the shaft, so as to act in succession on the projecting teeth of the upright rods or pestles. Each of these weighs 200 pounds, and works in a corresponding oblong mortar of stone or wood.

The *patio*, or amalgamation floor, Fig. 1272, is a large flat space, open to the sky, 312 feet in length, by 236 in breadth, and securely surrounded by strong walls. It is

1272



paved with large unhewn blocks of porphyry, and is capable of containing 24 *tortas*, or flat circular collections of *lama*, of about 50 feet diameter, and 7 inches deep, when the patio is not filled, (but of somewhat smaller dimensions when nearly so,) ranged in 4 rows, and numbered from the left-hand corner.

At one end a small space is generally set apart for the assays, which are made each on one monton.

The following description of Mexican amalgamation is given by Captain Lyon.

A *torta* of Zacatecas contains 60 montons of 20 quintals each, and is thus formed: — In the first instance, a square space, of the requisite size for a *torta*, is marked out, and enclosed by a number of rough planks, which are propped in their places on the patio floor by large stones, and dried horse-dung and dust are piled round their edges to prevent the escape of the *lama*. A heap of *saltierra* (salt mixed with earthy impurities) is then piled in the centre, in the proportion of 2 fanegas (each = 1.6 English bushels) and a half to the monton, = 150 for the *torta*. After this, the *lama*, or ore ground into a

fine paste, is poured in. When the last or 60th monton is delivered, the saltiera is shovelled down and well mixed with the lama, by treading it with horses, and turning it with shovels; after which the preparation is left at rest for the remainder of the day. On the following day comes the *el incorporo*. After about one hour's treading by horses, the magistral or roasted and pulverized copper ore is mixed with the lama, (the *repaso* or treading-mill still continuing,) in summer in the proportion of 15 cargass of 12 arrobas (25 lbs. each) to the torta, if the ore be of 6 marcos to the monton, and in winter in only half the quantity. For it is a singular fact, that in summer the mixture cools, and requires more warmth; while in winter it acquires of itself additional heat. With poorer ores, as for instance those of 4 marcos to the monton, 12 cargass are applied in summer, and 6 in winter. From November to February, lime is also occasionally used to cool the lama, in the proportion of about a peck per monton.

The *repaso*, or treading out, is continued by six horses, which are guided by one man, who stands in the lama, and directs them all by holding all their long halters. This operation is much more effectual in a morning than an evening, and occupies about five or six hours. When the magistral is well mixed, the quicksilver is applied, by being sprinkled through pieces of coarse cloth doubled up like a bag, so that it spurts out in very minute particles. The second treading of the horses then follows; after which the whole mixture is turned over by six men with wooden shovels, who perform the operation in an hour. The torta is then smoothed and left at rest for one entire day, to allow the incorporation to take place. It undergoes the turning by shovels and treading by horses every other day, until the amalgamator ascertains that the first admixture of quicksilver is found to be all taken up by the silver; and this he does by vanning or washing a small quantity of the torta in a little bowl. A new supply is then added, and when this has done its duty, another is applied to catch any stray particles of silver. On the same day, after a good *repaso*, the torta is removed on hand-barrows by the labourers, to the *lavaderos*, in order that it may receive its final cleansing. The general method of proportioning the quicksilver to the tortas, is by allowing that every marco of silver which is promised by trial of the ores as the probable produce of a monton, will require in the whole process 4 lbs.

In metals of five to six marcos and a half per monton (of the average richness of Zacatecas), 16 lbs. of quicksilver were incorporated for every monton, = 900 lbs. for the torta. On the day of the second addition, the proportion is 5 lbs. the monton; and when the torta is ready to receive the last dose of quicksilver, it is applied at the rate of 7 lbs. the monton, = 420 lbs.; making a total of 1620 lbs. of quicksilver. With poorer ores, less quicksilver and less magistral are required.

The usual time for the completion of the process of amalgamation, is from 12 to 15 days in the summer, and 20 to 25 in the winter. This is less than a third of the time taken at some other mines in Mexico. This rapidity is owing to the tortas being spread very flat, and receiving thereby the stronger influence of the sun. In the Mexican mines, only one monton is commonly mixed at a time; and the lama is then piled in a small conical heap or monton.

Lavadero, or washing vat. — Here the prepared tortas are washed, in order to carry off the earthy matters, and favour the deposition of the amalgam at the bottom. Each vat is about 8 feet deep, and 9 in diameter; and solidly built in masonry.

A large horizontal wheel, worked by mules, drives a vertical one, which turns a horizontal wheel fitted round a perpendicular wooden shaft, revolving upon an iron pivot at the bottom of the vat. To the lower end of this shaft, four cross-beams are fitted, from which long wooden teeth rise to the height of 5 feet. Their motion through the water being rapid, keeps all the lighter particles afloat, while the heavier sink to the bottom. The large wheel is worked by four mules, two at each extremity of the cross-beam. Water is supplied from an elevated tank. It requires 12 hours' work of one tub to wash a torta. Eight porters are employed in carrying the prepared lama of the tortas in hand-barrows to the vats. The earthy matter receives a second washing.

The amalgam is carried in bowls into the *azoguera*, where it is subjected to straining through the strong canvas bottom of a leather bag. The hard mass left in the bag is moulded into wedge-shaped masses of 30 lbs., which are arranged in the burning-house, (*fig. 1273.*), to the number of 11, upon a solid copper stand, called *base*, having a round hole in its centre. Over this row of wedges several others are built; and the whole pile is called *pisa*. Each circular range is firmly bound round with a rope. The base is

placed over a pipe which leads to a small tank of water for condensing the quicksilver; a cylindrical space being left in the middle of the *pisa*, to give free egress to the mercurial vapours.



A large bell-shaped cover, called *capellina*, is now hoisted up, and carefully lowered over the *pina*, by means of pulleys. A strong lute of ashes, *saltierra*, and *lama* is applied to its lower edge, and made to fit very closely to the plate on which the base stands. A wall of fire-bricks is then built loosely round the *capellina*, and this space is filled with burning charcoal, which is thrice replenished, to keep it burning all night. After the heat has been applied 20 hours, the bricks and ashes are removed, the luting broken, and the *capellina* hoisted up. The burned silver is then found in a hard mass, which is broken up, weighed, and carried to the casting-house, to be formed into bars of about 1080 ounces each. The loss of silver in burning, is about 5 ounces to each bar (*barra*), and the loss of quicksilver, from $2\frac{1}{2}$ upon the good metals, to 9 upon the coarse.

Molina told Mr. Miers, that the produce of the galena ores of Uspaltata did not average more than 2 marcs per *caxon* of 5000 lbs., which is an excessively poor ore. The argentiferous galena ores of Cumberland afford 11 marcs per *caxon*; while the average produce of the Potosi silver ores is only 5 or 6 marcs in the same quantity. These comparisons afford the clearest evidence that the English mode of smelting can never be brought into competition with the process of amalgamation as practised in America.

Humboldt, Gay Lussac, Boussingault, Karsten, and several other chemists of note, have offered solutions of the amalgamation enigma of Mexico and Peru. The following seems to be the most probable *rationale* of the successive steps of the process:—

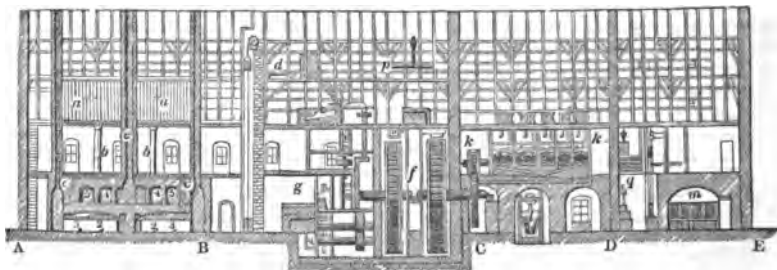
The addition of the *magistral* (powder of the roasted copper pyrites), is not for the purpose of disengaging muriatic acid from the sea salt (*saltierra*), as has been supposed, since nothing of the kind actually takes place; but, by reciprocal or compound affinity, it serves to form chloride of copper, and chloride of iron, upon the one hand, and sulphate of soda, upon the other. Were sulphuric acid to be used instead of the *magistral*, as certain novices have prescribed, it would certainly prove injurious, by causing muriatic acid to exhale. Since the ores contain only at times oxide of silver, but always a great abundance of oxide of iron, the acid would carry off both partly, but leave the chloride of silver in a freer state. A *magistral*, such as sulphate of iron, which is not in a condition to generate the chlorides, will not suit the present purpose; only such metallic sulphates are useful as are ready to be transformed into chlorides by the *saltierra*. This is peculiarly the case with sulphate of copper. Its deuto-chloride gives up chlorine to the silver, becomes in consequence a protochloride, while the chloride of silver, thus formed, is revived, and amalgamated with the quicksilver present, by electro-chemical agency which is excited by the saline menstruum; just as the voltaic pile of copper and silver is rendered active by a solution of sea salt. A portion of chloride of mercury will be simultaneously formed, to be decomposed in its turn by the sulphate of silver resulting from the mutual action of the acidified pyrites, and the silver or its oxide in the ore. An addition of quicklime counteracts the injurious effect of too much *magistral*, by decomposing the resulting sulphate of copper. Quicksilver being an excellent conductor of heat, when introduced in too great quantities, is apt to cool the mass too much, and thereby enfeebles the operation of the deuto-chloride of copper upon the silver.

There is a method of extracting silver from its ores by what is called *imbibition*. This is exceedingly simple, consisting in depriving, as far as possible, the silver of its gangue, then melting it with about its own weight of lead. The alloy thus procured, contains from 30 to 35 per cent. of silver, which is separated by cupellation on the great scale, as described under ores of lead. In this way the silver is obtained at Kongsberg in Norway.

The amalgamation works at Halsbrücke, near Freyberg, for the treatment of silver ores by mercury, have been justly admired as a model of arrangement, convenience, and regularity; and I shall conclude this subject with a sketch of their general distribution.

Fig. 1274. presents a vertical section of this great *usine* or *hüttenwerk*, subdivided into

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four main departments. The first, A, B, is devoted to the preparation and roasting of the matters intended for amalgamation. The second, B, C, is occupied with two successive

siftings and the milling. The third, c, d, includes the amalgamation apartment above, and the wash-house of the residuums below. And in the fourth, a, z, the distilling apparatus is placed, where the amalgam is finally delivered.

Thus, from one extremity of this building to the other, the workshops follow in the order of the processes; and the whole, over a length of 180 feet, seems to be a natural laboratory, through which the materials pass, as it were of themselves, from their crude to their refined condition; so skilfully economized and methodical are the labours of the workmen; such are the regularity, precision, concert, and facility, which pervade this long series of combinations, carriages, movements, and metamorphoses of matter.

Here we distinguish the following objects: —

1. In division A, z; a, a, is the magazine of salt; b, b, is the hall of preparation of the ores; on the floor of which they are sorted, interstratified, and mixed up with salt; c, c, are the roasting furnaces; in each of which we see, 1, the fireplace; 2, 3, the reverberatory hearth, divided into two portions, one a little higher than the other, and more distant from the fireplace, called the *drier*. The materials to be calcined fall into it, through a chimney 6. The other part 2, of the hearth is the calcining area. Above the furnace are chambers of sublimation 4, 5, for condensing some volatile matters which escape by the opening 7. e is the main chimney.

2. In the division z, c, we have d, the floor for the coarse sifting; beneath, that for the fine sieves; from which the matters fall into the hopper, whence they pass down to g, the mill-house, in which they are ground to flour, exactly as in a corn-mill, and are afterwards bouted through sieves. p, f, is the wheel machinery of the mill.

3. The compartment c, d, is the amalgamation work, properly speaking, where the casks are seen in their places. The washing of the residuums is effected in the shop l, below. h, k, is the compartment of revolving casks.

4. In the division d, z, the distillation process is carried on. There are four similar furnaces, represented in different states, for the sake of illustration. The wooden drawer is seen below, supporting the cast-iron basin, in which the tripod with its candelabra for bearing the amalgam saucers is placed. q is a store chamber.

At z, are placed the pulleys and windlass for raising the roasted ore, to be sifted and ground; as also for raising the milled flour, to be transported to the amalgamation casks. At d, the crane stands for raising the iron bells that cover the amalgamation candelabra.

Details of the Amalgamation Process, as practised at Halsbrücke. — All ores which contain more than 7 lbs. of lead, or 1 lb. of copper, per cent., are excluded from this reviving operation (*auquickverfahren*); because the lead would render the amalgam very impure, and the copper would be wasted. They are sorted for the amalgamation, in such a way that the mixture of the poorer and richer ores may contain $7\frac{1}{2}$ or, at most, 8 loths (of $\frac{1}{4}$ oz. each) of silver per 100 lbs. The most usual constituents of the ores are, sulphur, silver, antimonial silver (*speisglanzsilber*), bismuth, sulphurets of arsenic, of copper, iron, lead (nickel, cobalt), zinc, with several earthy minerals. It is essential that the ores to be amalgamated shall contain a certain proportion of sulphur, in order that they may decompose enough of sea salt in the roasting to disengage as much chlorine as to convert all the silver present into a chloride. With this view, ores poor in sulphur are mixed with those that are richer, to make up a determinate average. The ore-post is laid upon the *bed-floor*, in a rectangular heap, about 17 ells long, and $4\frac{1}{2}$ ells broad (13 yards and $3\frac{1}{4}$); and upon that layer the requisite quantity of salt is let down from the floor above, through a wooden tunnel; 40 cwts. of salt being allotted to 400 cwts. of ore. The heap being made up with alternate strata to the desired magnitude, must be then well mixed, and formed into small bings, called *roast-posts*, weighing each from $3\frac{1}{2}$ to $4\frac{1}{2}$ cwts. The annual consumption of salt at Halsbrücke is 6000 cwts.; it is supplied by the Prussian salt-works.

Roasting of the Amalgamation Ores. — The furnaces appropriated to the roasting of the ore-posts are of the reverberatory class, provided with soot chambers. They are built up alongside of the *bed-floor*, and connected with it by a brick tunnel. The prepared ground ore (*erzmehl*) is spread out upon the hearth, and dried with incessant turning over; then the fire is raised so as to kindle the sulphur, and keep the ore red-hot for one or two hours; during which time, dense white-gray vapours of arsenic, antimony, and water, are exhaled. The desulphuration next begins, with the appearance of a blue flame. This continues for three hours, during which the ignition is kept up; and the mass is diligently turned over, in order to present new surfaces, and to prevent any caking. Whenever sulphurous acid ceases to be formed, the finishing calcination is to be commenced with increased firing; the object being now to decompose the sea salt by means of the metallic sulphates that have been generated, to convert them into chlorides, with the simultaneous production of sulphate of soda. The stirring is to be continued till the proofs taken from the hearth no longer betray the smell of sulphurous, but only of muriatic acid gas. This roasting stage lasts commonly three quarters of an hour, 13 or 14 furnaces are worked at the same time at Halsbrücke; and each turns out in a

week 5 tons upon an average. Out of the *nicht* chambers or soot vaults of the furnaces, from 96 to 100 cwts. of ore-dust are obtained, containing 32 marcs (16 lbs.) of silver. This dust is to be treated like unroasted ore. The fuel of the first fire is pitcoal; of the finishing one, fir-wood. Of the former 115½ cubic feet, and of the latter, 294½, are, upon an average, consumed for every 100 cwts. of ore.

During the last roasting, the ore increases in bulk by one fourth, becomes in consequence a lighter powder, and of a brown colour. When this process is completed, the ore is raked out upon the stone pavement, allowed to cool, then screened in close sieve-boxes, in order to separate the finer powder from the lumps. These are to be bruised, mixed with sea salt, and subjected to another calcination. The finer powder alone is taken to the millstones, of which there are 14 pairs in the establishment. The stones are of granite, and make from 100 to 120 revolutions per minute. The roasted ore, after it has passed through the boulder of the mill, must be as impalpable as the finest flour.

The Amalgamation.—This (the *verquickten*) is performed in 20 horizontal casks, arranged in 4 rows, each turning upon a shaft which passes through its axis; and all driven by the water-wheel shown in the middle of *fig.* 1006. The casks are 2 feet 10 inches long, 2 feet 8 inches wide, inside measure, and are provided with iron ends. The staves are 3¼ inches thick, and are bound together with iron hoops. They have a double bungle-hole, one formed within the other, secured by an iron plug fastened with screws. They are filled by means of a wooden spout terminated by a canvas hose; through which 10 cwts. of the bouldered ore-flour (*erzmehl*) are introduced after 3 cwts. of water have been poured in. To this mixture, from ¾ to ⅞ of a cwt. of pieces of iron, 1¼ inch square, and ⅝ thick, are added. When these pieces get dissolved, they are replaced by others from time to time. The casks being two thirds full, are set to revolve for 1½ or 2 hours, till the ore-powder and water become a uniform pap; when 5 cwts. of quicksilver are poured into each of them. The casks being again made tight, are put in gear with the driving machinery, and kept constantly revolving for 14 or 16 hours, at the rate of 20 or 22 turns in the minute. During this time they are twice stopped and opened, in order to see whether the pap be of the proper consistence; for if too thick, the globules of quicksilver do not readily combine with the particles of ore; and if too thin, they fall and rest at the bottom. In the first case, some water must be added; in the second, some ore. During the rotation, the temperature rises, so that even in winter it sometimes stands so high as 104° F.

The chemical changes which occur in the casks are the following:—The metallic chlorides present in the roasted ore are decomposed by the iron, whence results muriate of iron, whilst the deutochloride of copper is reduced partly to protochloride, and partly to metallic copper, which throw down metallic silver. The mercury dissolves the silver, copper, lead, antimony, into a complex amalgam. If the iron is not present in sufficient quantity, or if it has not been worked with the ore long enough to convert the copper deutochloride into a protochloride, previously to the addition of the mercury, more or less of the last metal will be wasted by its conversion into protochloride (calomel). The water holds in solution sulphate of soda, undecomposed sea salt, with chlorides of iron, manganese, &c.

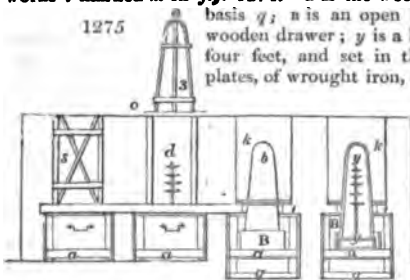
As soon as the revivification is complete, the casks must be filled with water, set to revolve slowly (about 6 or 8 times in the minute), whereby in the course of an hour, or an hour and a half at most, a great part of the amalgam will have collected at the bottom; and in consequence of the dilution, the portion of horn silver held in solution by the sea salt will fall down and be decomposed. Into the small plug in the centre of the bung, a small tube with a stopcock is now to be inserted, to discharge the amalgam into its appropriate chamber. The cock must be stopped whenever the brown muddy residuum begins to flow. The main bung being then opened, the remaining contents of the casks are emptied into the *wash-tub*, while the pieces of iron are kept back. The residuary ore is found to be stripped of its silver within ⅓ or ⅞ of an ounce per cwt. The emptying of all the casks, and charging them again, takes 2 hours; and the whole process is finished within 18 or 20 hours; namely, 1 hour for charging, 14 to 16 hours for amalgamating; 1½ hour for diluting; 1 hour for emptying. In 14 days, 3200 cwts. of ore are amalgamated. For working 100 cwts. of ore, 14½ lbs. of iron, and 2 lbs. 12½ ounces of mercury, are required; whence, for every pound of silver obtained, 0·95 of an ounce of mercury are consumed.

Trials have been made to conduct the amalgamation process in iron casks, heated to 150° or 160° Fahrenheit, over a fire; but though the de-silvering was more complete, the loss by mercury was so much greater as to more than counterbalance that advantage.

Treatment of the Amalgam.—It is first received in a moist canvas bag, through which the thin uncombined quicksilver spontaneously passes. The bag is then tied up and subjected to pressure. Out of 20 casks, from 3 to 3½ cwts. of solid amalgam are thus procured, which usually consist of 1 part of an alloy, containing silver of 12 or 13 *loths* (in 16), and 6 parts of quicksilver. The foreign metals in that alloy are, copper, lead,

gold, antimony, cobalt, nickel, bismuth, zinc, arsenic, and iron. The filtered quicksilver contains moreover 2 to 3 loths of silver in the cwt.

Fig. 1275. represents the apparatus for distilling the amalgam in the Halabrücke works; marked *m* in *fig.* 1274. *a* is the wooden drawer, sliding in grooves upon the



basis *g*; *z* is an open basin or box of cast iron, laid in the wooden drawer; *y* is a kind of iron candelabra, supported upon four feet, and set in the basin *z*; under *d* are five dishes or plates, of wrought iron, with a hole in the centre of each, whereby they are fitted upon the stem of the candelabra, 3 inches apart, each plate being successively smaller than the one below it. 3 indicates a cast-iron bell, furnished with a wrought-iron frame and hook, for raising it by means of a pulley and cord. *s* is a sheet-iron door for closing the stove, whenever the bell has been set in its place.

The box *a*, and the basin *z*, above it, are filled with water, which must be continually renewed, through a pipe in the side of the wooden box, so that the iron basin may be kept always submersed and cool. The drawer *a*, being properly placed, and the plates under *d* being charged with balls of amalgam (weighing altogether 3 cwts.), the bell 3 is to be let down into the water, as at *y*, and rested upon the lower part of the candelabra. Upon the ledge *l*, which defines the bottom of the fireplace, a circular plate of iron is laid, having a hole in its middle for the bell to pass through. Upon this plate chips of fir-wood are kindled, then the door *s*, which is lined with clay, is closed and luted tight. The fuel is now placed in the vacant space *k*, round the upper part of the bell. The fire must be fed in most gradually, first with turf, then with charcoal; whenever the bell gets red, the mercury volatilises, and condenses in globules into the bottom of the basin *z*. At the end of 8 hours, should no more drops of mercury be heard to fall into the water, the fire is stopped. When the bell has become cool, it is lifted off; the plates are removed from the candelabra *d*; and this being taken out, the drawer *a* is slid away from the furnace. The mercury is drained, dried, and sent again into the amalgamation works. The silver is sent and refined by cupellation.

The solid amalgam which is distilled in the above apparatus, would be distilled more profitably out of iron trays set in the mercurial retorts described and figured in pages 138, 139 of Vol. II.

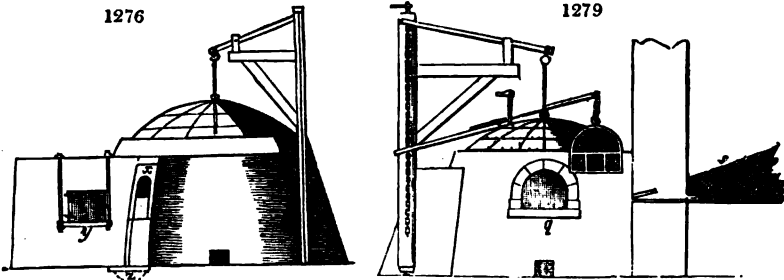
From 3 cwts. of amalgam, distilled under the bell, from 95 to 100 marcs ($\frac{1}{4}$ lbs.) of *teller* silver (dish silver) are procured, containing from 10 to 13 $\frac{1}{2}$ parts of fine silver out of 16; one-fifth part of the metal being copper. The *teller* silver is refined in quantities of 160 or 170 marcs, in black-lead crucibles filled within two inches of their brims, and submitted to brisk ignition. The molten mass exhales some vapours, and throws up a liquid slag, which being skimmed off, the surface is to be strewed over with charcoal powder, and covered with a lid. The heat having been briskly urged for a short time, the charcoal is then removed along with any fresh slag that may have risen, in order to observe whether the vapours have ceased. If not, fresh charcoal must be again applied, the crucible must be covered, and the heat increased, till fumes are no longer produced, and the surface of the silver becomes tranquil. Finally, the alloy, which contains a little gold, and much copper, being now from 11 to 13 *lothig* (that is, holding from 11 to 13 parts of fine silver in 16 parts), is cast into iron moulds, in ingots of 60 marcs. The loss of weight by evaporation and skimming of the slag amounts to 3 per cent.; the loss in silver is quite inconsiderable.

The dust from the furnace (*Stiegelisfen*) is collected in a large condensation chamber of the chimney, and affords from 40 to 50 marcs of silver per cwt. The slags and old crucibles are ground and sent to the small amalgamation mill.

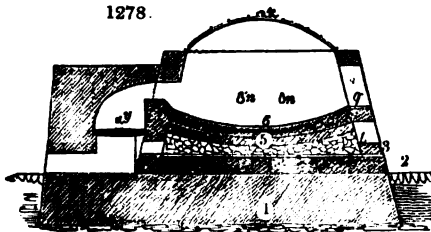
The earthy residuum of the amalgamation casks being submitted to a second amalgamation, affords out of 100 cwts. about 2 lbs. of coarse silver. This is first fused along with three or four per cent. of a mixture of potashes and calcined quicksiltz, (impure sulphate of soda), and then refined. The supernatant liquor that is drawn out of the tanks in which the contents of the casks are allowed to settle, consists chiefly of sulphate of soda, along with some common salt, sulphates of iron and manganese, and a little phosphate, arseniate, and fluuate of soda. The earthy deposit contains from $\frac{1}{4}$ to $\frac{3}{8}$ of a *loth* of silver per cwt., but no economical method of extracting this small quantity has yet been contrived.

The argentiferous or *rich lead* is treated in Germany by the cupellation furnace represented in *figs.* 1276, 1277, 1278, and 1279. These figures exhibit the cupellation furnace of the principal smelting work in the Hartz, where the following parts must be

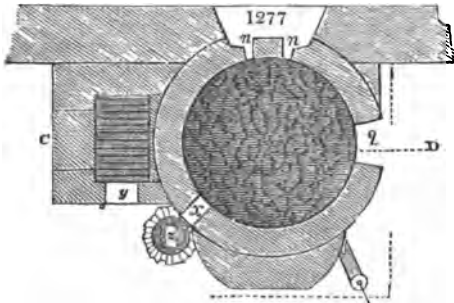
distinguished; (*fig. 1278.*) 1, masonry of the foundation; 2, flues for the escape of moisture; 3, stone covers of the flues; 4, bed of hard rammed scoria; 5, bricks set on edge, to form the permanent area of the furnace; 6, the sole, formed of wood ashes, washed, dried, and beaten down; *k*, dome of iron plate, movable by a crane, and susceptible of being lined two inches thick with loam; *n*, *z*, tuyères for two bellows *s*; having valves suspended before their orifices to break and spread the blast; *q*, door for introducing into the furnace the charge of lead, equal to 84 quintals at a time; *s*, *fig.*



1011., two bellows, like those of a smith's forge; *y*, door of the fireplace, through which billets of wood are thrown on the grate; *x*, small aperture or door, for giving issue to the



this floor a circular space, somewhat lower than the rest of the hearth, where the silver ought to gather at the end of the operation. The cupel is fully six feet in diameter.



nothing. The movable lid is now luted on the furnace, and heat is slowly applied in the fireplace, by burning fagots of fir-wood, which is gradually raised. Section 1278. is in the line *c, n*, of 1277.

At the end of three hours, the whole lead being melted, the instant is watched for when no more ebullition can be perceived on the surface of the bath or melted metal; then, but not sooner, the bellows are set a playing on the surface at the rate of 4 or 5 strokes per minute, to favour the oxidizement.

In five hours, reckoned from the commencement of the process, the fire is smartly raised; when a grayish froth (*abstrich*) is made to issue from the small aperture *x* of the furnace. This is found to be a brittle mixture of oxidized metals and impurities. The workman now glides the rake over the surface of the bath, so as to draw the froth out of the furnace; and, as it issues, powdered charcoal is strewed upon it, at the aperture *x*, to cause its coagulation. The froth skimming lasts for about an hour and a half.

frothy scum of the cupellation, and the litharge; *z*, basin of safety, usually covered with a stone slab, over which the litharge falls: in case of accident the basin is laid open to admit the rich lead.

The following is the mode of conducting the cupellation. Before putting the lead into the furnace, a floor is made in it of ashes beat carefully down (see 6, *fig. 1278.*); and there is left in the centre of

In forming the floor of a cupel, 35 cubic feet of washed wood ashes, usually got from the soap works, are employed. The preparation of the floor requires 2½ hours' work; and when it is completed, and the movable dome of iron plate has been lined with loam, 84 quintals (cwt.) of lead are laid on the floor, 42 quintals being placed in the part of the furnace farthest from the bellows, and 42 near to the fire-bridge; to these, scoria containing lead and silver are added, in order to lose

After this time, the litharge begins to form, and it is also let off by the small opening x ; its issue being aided by a hook. In proportion as the floor of the furnace gets impregnated with litharge, the workman digs in it a gutter for the escape of the liquid litharge: it falls in front of the small aperture, and concretes in stalactitic forms.

By means of the two movable valves suspended before the tuyères a, a , (fig. 1278.) the workman can direct the blast as he will over the surface of the metal. The wind should be made to cause a slight curl on the liquid, so as to produce circular undulations, and gradually propel a portion of the litharge generated, towards the edges of the cupel, and allow this to retain its shape till the end of the operation. The stream of air should drive the greater part of the litharge towards the small opening x , where the workman deepens the outlet for it, in proportion as the level of the metal bath descends, and the bottom of the floor rises by the apposition of the litharge formed. Litharge is thus obtained during about 12 hours; after which period the cake of silver begins to take shape in the centre of the cupel.

Towards the end of the operation, when no more than four additional quintals of litharge can be looked for, and when it forms solely in the neighbourhood of the silver cake in the middle of the floor, great care must be taken to set apart the latter portions, because they contain silver. About this period, the fire is increased, and the workman places before the little opening x a brick, to serve as a mound to the efflux of litharge. The use of this brick is,— 1, to hinder the escape of the silver in case of any accident; for example, should an explosion take place in the furnace; 2, to reserve a magazine of litharge, should that still circulating round the silver cake be suddenly absorbed by the cupel, for in this dilemma the litharge must be raked back on the silver; 3, to prevent the escape of the water that must be thrown on the silver at the end of the process.

When the argentiferous litharge, collected in the above small magazine, is to be removed, it is let out in the form of a jet, by the dexterous use of the iron hook.

Lastly, after 20 hours, the silver cake is seen to be well formed, and nearly circular. The moment for stopping the fire and the bellows is indicated by the sudden disappearance of the coloured particles of oxide of lead, which, in the latter moments of oxidation, undulate with extreme rapidity over the slightly convex surface of the silver bath, moving from the centre to the circumference. The phenomenon of their total disappearance is called the *lightning*, or fulguration. Whenever this occurs, the plate of silver being perfectly clean, there is introduced into the furnace, by the door g , a wooden spout, along which water, previously heated, is carefully poured on the silver.

The cupellation of 84 quintals of argentiferous lead takes in general 18 or 20 hours' working. The promptitude of the operation depends on the degree of purity of the leads employed, and on the address of the operator, with whom also lies the economy of fuel. A good workman completes the cupellation of 84 quintals with 300 billets, each equivalent to a cubic foot and eight-tenths of wood (Hartz measure); others consume 400 billets, or more. In general, the cupellation of 100 quintals of lead, executed at the rate of 84 quintal charges, occasions a consumption of 790 cubic feet of resinous wood billets.

The products of the charge are as follow:—

| | | |
|---|---|-------------------|
| 1. Silver, holding in 100 marcs, 7 marcs and 3 loths of alloy | - | 24 to 30 marcs. |
| 2. Pure litharge, containing from 88 to 90 per cent. of lead | - | 50 - 60 quintals. |
| 3. Impure litharge, holding a little silver | - | 2 - 6 — |
| 4. Skimmings of the cupellation | - | 4 - 8 — |
| 5. Floor of the furnace impregnated with litharge | - | 22 - 30 — |

NOTE.— The marc is 7 oz. 2 dwts. 4 gr. English troy; and the loth is half an ounce. 16 loths make a marc. 100 pounds Cologne are equal to 103 pounds avoirdupois; and the above quintal contains 116 Cologne pounds.

The loss of lead inevitable by this operation, is estimated at 4 parts in 100. It has been diminished as much as possible in the Frankscharn works of the Hartz, by leading the smoke into long flues, where the lead fumes are condensed into a metallic soot. The silver cake receives a final purification at the Mint, in a cupel on a smaller scale.

From numerous experiments in the great way, it has been found that not more than 100 quintals of lead can be profitably cupelled at one operation, however large the furnace, and however powerful and multiplied the bellows and tuyères may be; for the loss on either the lead or the silver, or on both, would be increased. In one attempt, no less than 500 quintals were acted on, in a furnace with two fireplaces, and four escapes for the litharge; but the silver remained disseminated through the lead, and the lightning could not be brought on. The chief object in view was economy of fuel.

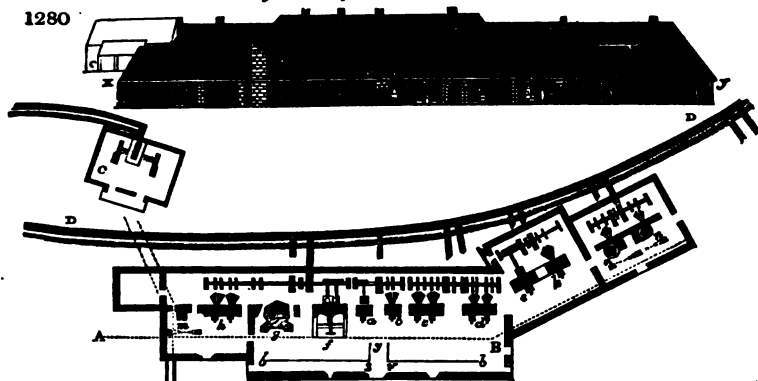
Reduction of the Litharge.— This is executed in a slag-hearth, with the aid of wood charcoal.

Such is the train of operations by which the cupriferous galena *schlich*, or ground ore

is reduced, in the district of Clausthal, into lead, copper, and silver. The works of Frankenscharn have a front fully 400 feet long.

Fig. 1279. exhibits the plan and elevation of these smelting-works, near Clausthal, in the Hartz, for lead ores containing copper and silver, where about 84,000 cwts. of

Silver-smelting Works of Frankenscharn, near Clausthal.



schlich (each of 123 Cologne pounds) are treated every year. This quantity is the produce of 90 distinct mines, as also of nearly as many stamp and preparation works. All these different *schlichs*, which belong to so many different joint-stock companies, are confounded and worked up together in the same series of metallurgic operations; the resulting mixture being considered as one and the same ore belonging to a single undertaking; but in virtue of the order which prevails in this royal establishment, the rights of each of the companies, and consequently of each shareholder, are equitably regulated. A vigorous control is exercised between the mines and the stamps, as also between the stamps and the smelting-houses; while the cost of the metallurgic operations is placed under the officers of the crown, and distributed, upon just principles, among the several mines, according to the quantities of metal furnished by each.

From these arrangements, the following important advantages flow: —

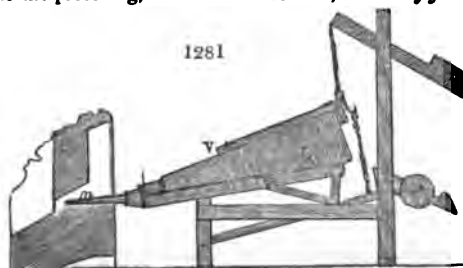
1. The poor ores may be smelted with profit, without putting the companies to any risk or expense in the erection of new works; 2, by the mixture of many different ores, the smelting and metallic product become more easy and abundant; 3, the train of the operations is conducted with all the lights and resources of science; and 4, the amount of metal brought into the market is not subject to such fluctuations as might prove injurious to their sale.

The following is the series of operations: —

1. The fusion of the *schlich* (sludge); 2, the roasting of the mattes under a shed, and their treatment by four successive re-meltings; 3, the treatment of the resulting black copper; 4, the liquation; 5, the reliquation (*ressuage*); 6, the refining of the copper; 7, the cupellation of the silver; 8, the reduction of the litharge into lead. The 5th and 6th processes are carried on at the smelting works of Altenuau.

The buildings are shown at *a, a, c*, and the impelling stream of water at *d*; the upper figure being the elevation; the lower, the plan of the works.

a, is the melting furnace, with a cylinder bellows behind it; *b, c, d*, furnaces similar to the preceding, with wooden bellows, such as *fig. 1281*; *e*, is a furnace for the same



purpose, with three tuyères, and a cylinder bellows; *f*, the large furnace of fusion, also with three tuyères; *g*, a furnace with seven tuyères, now seldom used; *h*, low furnaces, like the English slag-hearths (*Arummo-fen*), employed for working the last mattes; *h*, slag-hearths for reducing the litharge; *m*, the area of the liquation; *n, p*, cupellation furnaces.

x, y, a floor which separates

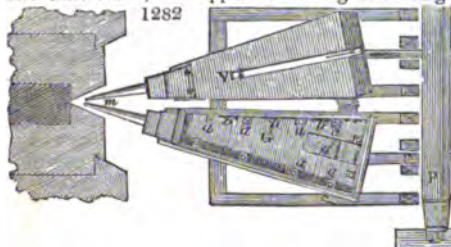
the principal smelting-house into two stories; the materials destined for charging the furnaces being deposited in beds upon the upper floor, to which they are carried by means of two inclined planes, terraced in front of the range of buildings.

Here 89,600 quintals of schlich are annually smelted, which furnish —

| | | | | | | |
|--|---|---|---|---|--------|-----------|
| Marketable lead | - | - | - | - | 20,907 | quintals. |
| Marketable litharge, containing 90 per cent. of lead | - | - | - | - | 7,555 | |
| Silver, about | - | - | - | - | 67 | |
| Copper (finally purified in the works of Altenau) | - | - | - | - | 35 | |
| <hr/> | | | | | | |
| Total product | - | - | - | - | 28,564 | |

This weight amounts to one twenty-fifth of the weight of ore raised for the service of the establishment. Eight parts of ore furnish, on an average, about one of schlich. The bellows are constructed wholly of wood, without any leather; an improvement made by a bishop of Bamberg, about the year 1620. After receiving different modifications, they were adopted, towards 1730, in almost all the smelting-works of the continent, except in a few places, as Carniola, where local circumstances permitted a water blowing-machine to be erected. These pyramidal shaped bellows, composed of movable wooden boxes, have, however, many imperfections: their size must often be inconveniently large, in order to furnish an adequate stream of air; they do not drive into the furnace all the air which they contain; they require frequent repairs; and, working with great friction, they waste much mechanical power.

Fig. 1282. represents such wooden bellows, consisting of two chests or boxes, fitted into each other; the upper or moving one being called the *fly*, the lower or fixed

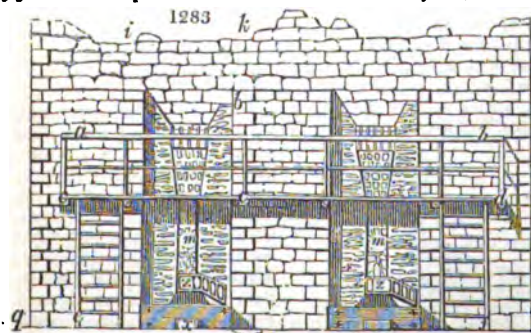


one, the *seat* (*gite*). In the bottom of the *gite*, there is an orifice furnished with a clack-valve *d*, opening inwards when the *fly* is raised, and shutting when it falls. In order that the air included in the capacity of the two chests may have no other outlet than the nose-pipe *m*, the upper portion of the *gite* is provided at its four sides with small square slips of wood *c, c, c,*

which are pressed against the sides of the *fly* by strong springs of iron wire *b, b, b,* while they are retained upon the *gite* by means of small square pieces of wood *a, a, a, a.* The latter *a, a,* are perforated in the centre, and adjusted upon rectangular stems, called *buchettes*; they are attached, at their lower ends, to the upright sides of the *gite*. *r* is the driving-shaft of a water-wheel, which, by means of cams or tappets, depresses the *fly*, while the counterweight *q*, fig. 1013., raises it again.

Figs. 1283, 1284, 1285, 1286. represent the moderately high (*demihauts*, or *half-blast*.) furnaces employed in the works of the lower Hartz, near Goslar, for smelting the silvery lead ores extracted from the mine of Rammelsberg. See its section, in p. 189, Vol. II.

Fig. 1283. is the front elevation of the twin furnaces, built in one body of masonry; Fig. 1284. is a plan taken at the level of the tuyères, in the line *v, l, 6.* of fig. 1285;

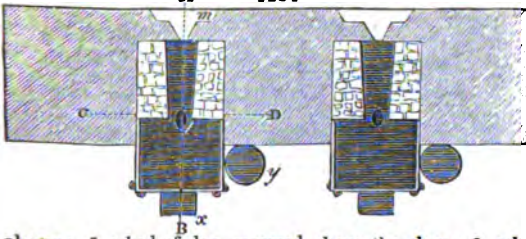


figs. 1285. and 1286. exhibit two vertical sections; the former in the line *A, B,* the latter in the line *c, d,* of fig. 1284. In these four figures the following objects may be distinguished.

a, b, c, d, a balcony or platform, which leads to the place of charging *a*;
e, f, wooden stairs, by which the charging workmen mount from *g* the ground *p, q,* of the works, to the platform;

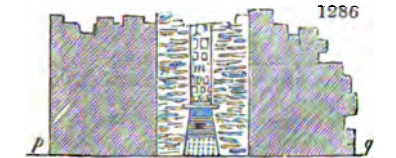
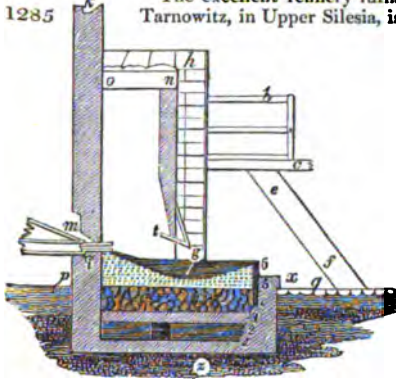
g, h, brickwork of the furnaces; *i, k,* wall of the smelting-works, against which they are supported; *l,* upper basin of reception, hollowed out of the *brasque* (or ground charcoal bed) *6*; *m,* arch of the tuyère *v,* by which each furnace receives the blast of two

bellows; *n*, place of charging, which takes place through the upper orifice *n*, *o*, of the basin *n*, *o*, *v*, *t*, of the furnace; *t*, a slab of clay, placed in such a way that, during the treatment of the lead, a little metallic zinc may run together in a sloping gutter, seen in *fig.* 1269., formed of slates cemented together with clay.



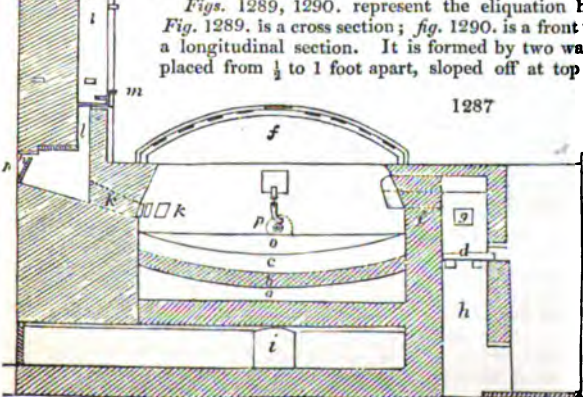
In *figs.* 1283 and 1285., 1, 2, is the brickwork of the foundations; *m*, conduits (called evaporatory), for the exhalation of the moisture; 4, a layer of slags, rammed above; 5, a bed of clay, rammed above the slags; 6, a brasque, composed of one part of clay, and two parts of ground charcoal, which forms the sole of the furnace.

The excellent refinery furnace, or *treibherd*, of Frederickshütte, near Tarnowitz, in Upper Silesia, is represented in *figs.* 1287. and 1288. *a*, is the bottom, made of slag or cinders; *b*, the foundation, of fire-bricks; *c*, the body of the hearth proper, composed of a mixture of 7 parts of dolomite, and 1 of fire-clay, in bulk; *d*, the grate of the air furnace; *e*, the fire-bridge; *f*, the dome or cap, made of iron plate strengthened with bars, and lined with clay-lute, to protect the metal from burning; *g*, the door of the fireplace; *h*, the ash-pit; *i*, the tap-hole; *k*, *k*, the flue, which is divided by partitions into several channels; *l*, the chimney; *m*, a damper-plate for regulating the draught; *n*, a back valve, for admitting air to cool the furnace, and brushes to sweep the flues; *o*, *tuyère* of copper, which by means of an iron wedge may be sloped more or less towards the hearth; *p*, the *schnepper*, a round piece of sheet iron, hung before the *eye* of the *tuyère*, to break and spread the blast; *q*, the outlet for the glassy litharge.



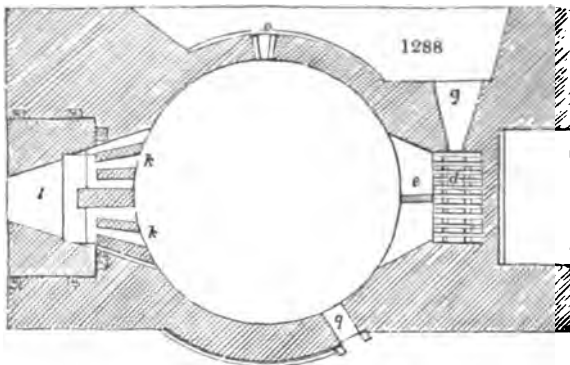
Lime-marl has been found to answer well for making the body of the hearth-sole, as it absorbs the vitrified litharge freely, without combining with it. A basin-shaped hollow is formed in the centre, for receiving the silver at the end of the process; and a gutter is made across the hearth for running off the *glätte* or fluid litharge.

Figs. 1289, 1290. represent the eliquation hearth of Neustadt. *Fig.* 1289. is a cross section; *fig.* 1290. is a front view; and *fig.* 1291. a longitudinal section. It is formed by two walls *a*, *a*, 3½ feet high, placed from ½ to 1 foot apart, sloped off at top with iron plates, 3 inches thick, and 18 inches broad, called *saigerscharten*, or refining plates, *b*, *b*, inclined 3 inches towards each other in the middle, so as to leave at the lowest point a slit 2¼ inches wide between them, through which the lead, as it sweats out by the heat, is allowed to fall into



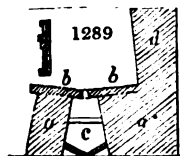
1287

the space between the two walls *c*, called the *saigergasse* (sweating-gutter). The sole of this channel slopes down towards the front, so that the liquified metal may run off



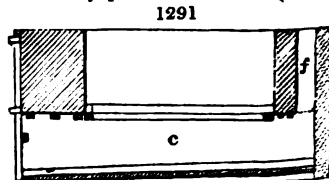
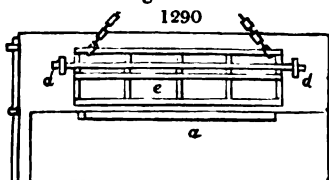
into a crucible or pot. Upon one of the long sides, and each of the shorter ones, of the hearth, the walls *d, d*, are raised two feet high, and upon these the liquation lumps rest; upon the other long side, where there is no wall, there is an opening for admitting these lumps into the hearth. The openings are then shut with a sheet or cast iron plate *e*, which, by means of

a chain, pulley, and counterweight, may be easily raised and lowered. *f*, is a passage for increasing the draught of air.

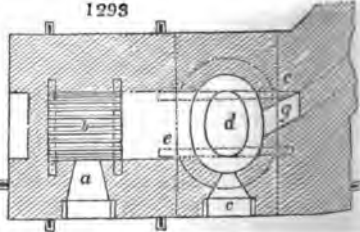
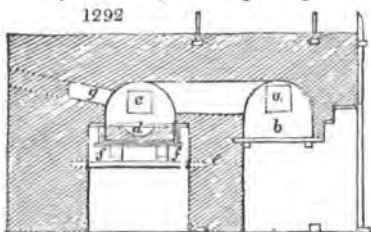


Figs. 1291. and 1294. represent the refining furnaces of Frédrickshütte by Tarnowitz; *a*, is the fire-door; *b*, the grate; *c*, the door for introducing the silver; *d*, the movable test, resting upon a couple of iron rods *e, e*, which are let at their ends into the brickwork. They lie lower than would seem to be necessary; but this is done in order to be able to place the surface of the test at any desired level, by placing tiles *f, f*, under it; *g*, the flue, leading to a chimney 18 feet high. For the refining of 100 pitcoal are required. The test or cupel must be heated before the impure silver and soft lead are put into it.

At these smelting-houses from 150 to 160 cwt. of very pure workable lead (lead con-



taining merely a little silver) are put into the furnace at once, and from 10 to 14 cwt. run off in vitrified oxide; the remainder is then refined with some pure lead, when an alloy containing from 14½ to 15½ loths of blicksilver per cwt. is obtained.



English refining furnaces. — The refining of lead is well performed in some works in the neighbourhood of Alston-moor, in reverberatory furnaces, *figs.* 1294. and 1295., whose fireplace is 22 inches square, and is separated from the sole by a fire-bridge, 14 inches in breadth. The flame, after having passed over the surface of the lead in the cupel, enters two flues *e, e*, on the opposite side of the furnace, which terminate in a chimney *i, i, i*, 40 feet high. At the bottom of the chimney are openings *f, f*, for taking out the metallic dust deposited within. These openings are shut during the process.

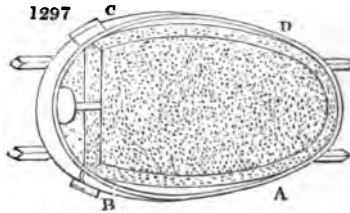
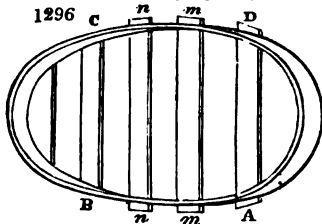
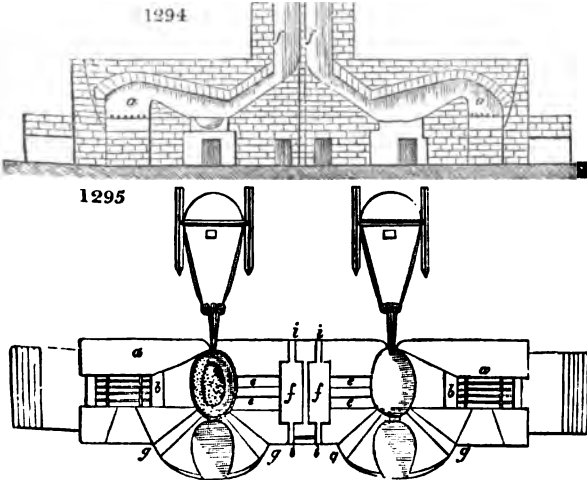
The cupel or test, which constitutes, in fact, the sole of the hearth in which the operation takes place, is movable. It consists of a vertical elliptical ring of iron,

A, B, C, D, *figs.* 1296. and 1297., $3\frac{3}{4}$ inches high, the greatest diameter of the ellipse being 4 feet, and the smallest 2 $\frac{1}{2}$. Four iron bars (A D, m, m', B C, n, n') are fixed across its

bottom, which are also $3\frac{3}{4}$ inches broad, and an inch thick. The first of these bars is placed 9 inches from the end of the elliptic ring nearest the fireplace, and the three others are equally distributed between this bar and the back end.

In forming the cupel, several layers of a mixture of moistened bone ashes, and fern ashes, in very fine powder, are put into the *test-frame*. The bone ash constitutes from $\frac{1}{4}$ to $\frac{1}{3}$ of the bulk of the mixture, according to the purity of the

fern ashes employed, estimated by the proportion of potash they contain, which has the property of semi-vitrifying the powder of burnt bones, of thus removing its friability, and



rendering it more durable. The layers of ashes are strongly beat down, till the frame is entirely filled. The mass thus formed is then hollowed out by means of a little spade, made on purpose, till it is only three quarters of an inch thick above the iron bars near the centre of the bottom. A flange, 2 inches broad, is made at the upper part, and 2 $\frac{1}{2}$ inches at the lower part, except on the front or *breast*, which is 5 inches thick. In this anterior part, there is hollowed out an opening of an inch and a quarter broad, and 6 inches long, with which the outlet or *gateway* of the litharge communicates.

The cupel thus prepared is placed in the refining furnace. It rests in an iron ring built into the brickwork. The arched roof of the furnace is 12 inches above the cupel near the fire-bridge, and 9 inches near the flue at the other end.

The tuyère is placed in the back of the furnace, opposite to the side at which the litharge is allowed to overflow.

Openings *g, g*, are left at the sides of each cupel, either for running off or for introducing melted lead.

Refining of lead to extract its silver. — This operation, which the lead of Derbyshire cannot be submitted to with advantage, is performed in a certain number of the smelting-houses at Alston-moor, and always upon leads reduced in the Scotch furnace.

The cupel furnace above described, must be slowly heated, in order to dry the cupel without causing it to crack, which would infallibly be produced by sudden evaporation of the moisture in it. When it has been thus slowly brought to the verge of a red heat, it is almost completely filled with lead previously melted in an iron pot. The cupel may be charged with about 5 cwt. At the temperature at which the lead is introduced, it is immediately covered with a gray pellicle of oxide; but when the heat of the furnace has been progressively raised to the proper pitch, it becomes whitish-red, and has its surface covered over with litharge. Now is the time to set in action the blowing-machine, the blast of which, impelled in the direction of the great axis of the cupel, drives the litharge towards the *breast* of the cupel, and makes it flow out by the *gateway* prepared for it, through which it falls upon a cast-iron plate, on a level with the

floor of the apartment, and is dispersed into tears. It is carried in this state to the furnace of reduction, and revived. As by the effect of the continual oxidization which it undergoes, the surface of the metal necessarily falls below the level of the gateway of the litharge, melted lead must be added anew by ladling it into the furnace from the iron boiler, as occasion may require. The operation is carried on in this manner till 84 cwt. or 4 Newcastle *fodders* of lead have been introduced, which takes from 16 to 18 hours, if the tuyère has been properly set. The whole quantity of silver which this mass of lead contains, is left in combination with about 1 cwt. of lead, which, under the name of rich lead, is taken out of the cupel.

When a sufficient number of these pieces of rich lead have been procured, so that by their respective quality, as determined by assaying, they contain in whole from 1000 to 2000 ounces of silver, they are re-melted to extract their silver, in the same furnace, but in a cupel which differs from the former in having at its bottom a depression capable of receiving at the end of the process the cake of silver. In this case a portion of the bottom remains uncovered, on which the scorise may be pushed aside with a little rake, from the edges of the silver.

The experiments of MM. Lucas and Gay Lussac have proved that fine silver, exposed to the air in a state of fusion, absorbs oxygen gas, and gives it out again in the act of consolidation. The quantity of oxygen thus absorbed may amount to twenty-two times the volume of the silver. The following phenomena are observed when the mass of metal is considerable; for example, from 40 to 50 pounds.

The solidification commences at the edges, and advances towards the centre. The liquid silver, at the moment of its passage to the solid state, experiences a slight agitation, and then becomes motionless. The surface, after remaining thus tranquil for a little, gets all at once irregularly perturbed, fissures appear in one or several lines, from which flow, in different directions, streams of very fluid silver, which increase the original agitation. The first stage does not yet clearly manifest the presence of gas, and seems to arise from some intestine motion of the particles in their tendency to group, on entering upon the process of crystallization, and thus causing the rupture of the envelop or external crust, and the ejection of some liquid portions.

After remaining some time tranquil, the metal presents a fresh appearance, precisely analogous to volcanic phenomena. As the crystallization continues, the oxygen gas is given out with violence at one or more points, carrying with it melted silver from the interior of the surface, producing a series of cones, generally surmounted by a small crater, vomiting out streams of the metal, which may be seen boiling violently within them.

These cones gradually increase in height by the accumulation of metal thrown up, and that which becomes consolidated on their sloping sides. The thin crust of metal on which they rest, consequently experiences violent impulses, being alternately raised and depressed by such violent agitation, that were it not for the tenacity and elasticity of the metal, there would evidently arise dislocation, fissures, and other analogous accidents. At length several of the craters permanently close, while others continue to allow the gas a passage. The more difficult this is, the more the craters become elevated, and the more their funnels contract by the adhesion or coagulation of a portion of the metal. The projection of globules of silver now becomes more violent; the latter being carried to great distances, even beyond the furnace, and accompanied by a series of explosions, repeated at short intervals. It is generally the last of these little volcanoes that attains the greatest altitude, and exhibits the foregoing phenomena with the greatest energy. It is, moreover, observable, that these cones do not all arise at the same time, some having spent their force, when others commence forming at other points. Some reach the height of an inch, forming bases of two or three inches in diameter. The time occupied by this exhibition is at least from half to three quarters of an hour.

During the formation of these cones, by the evolution of gas, portions of silver are shot forth, which assume, on induration, a form somewhat cylindrical, and often very fantastick, notwithstanding the incompatibility which appears to exist between the fluidity of the silver and these elongated figures. Their appearance is momentary, and without any symptoms of gas, although it is impossible to decide whether they may not arise from its influence; they seem, in fact, to resemble the phenomena of the first volcanic period.

Till very recently the only operations employed for separating silver from lead in the English smelting-works, were the following:—

1. Cupellation, in which the lead was converted into a vitreous oxide, which was floated off from the surface of the silver.
2. Reduction of that oxide, commonly called litharge.
3. Smelting the bottoms of the cupels, to extract the lead which had soaked into them, in a glassy state.

Cupellation and its two complementary operations were, in many respects, objectionable processes; from the injurious effects of the lead vapours upon the health of the workmen; from the very considerable loss of metallic lead, amounting to 7 per cent. at least; and, lastly, from the immense consumption of fuel, as well as from the vast amount of manual labour incurred in such complicated operations. Hence, unless the lead were tolerably rich in silver, it would not bear the expense of cupellation.

The patent process lately introduced by Mr. Pattinson, of Newcastle, is not at all prejudicial to the health of workmen; it does not occasion more than 2 per cent. of loss of lead, and in other respects it is so economical, that it is now profitably applied in Northumberland to alloys too poor in silver to be treated by cupellation. This process is founded upon the following phenomena.

After melting completely an alloy of lead and silver, if we allow it to cool very slowly, continually stirring it meanwhile with a rake, we shall observe at a certain period a continually increasing number of imperfect little crystals, which may be taken out with a drainer, exactly as we may remove the crystals of sea salt deposited during the concentration of brine, or those of sulphate of soda, as its agitated solution cools. On submitting to analysis the metallic crystals thus separated, and also the liquid metal deprived of them, we find the former to be lead almost alone, but the latter to be rich in silver, when compared with the original alloy. The more of the crystalline particles are drained from the metallic bath, the richer does the *mother* liquid become in silver. In practice, the poor lead is raised by this means to the standard of the ordinary lead of the litharge works; and the better lead is made ten times richer. This very valuable alloy is then submitted to cupellation; but as it contains only a tenth part of the quantity of lead subjected to crystallization, the loss in the cupel will be obviously reduced to one-tenth of what it was by the former process; that is, $\frac{1}{10}$ of a per cent., instead of 7.

These nine-tenths of the lead separated by the drainer, are immediately sent into the market, without other loss than the trifling one, of about $\frac{1}{4}$ per cent., involved in reviving a little dross skimmed off the surface of the melted metal at the beginning of the operation. Hence the total waste of lead in this method does not exceed 2 per cent. And as only a small quantity of lead requires to be cupelled, this may be done with the utmost slowness and circumspection; whereby loss of the precious metal, and injury to the health of the workpeople, are equally avoided.

The crystallization refinery of Mr. Pattinson is an extremely simple smelting-house. It contains 3 hemispherical cast-iron pans, 41 inches in diameter, and $\frac{1}{4}$ of an inch thick. The three pans are built in one straight line, the broad flange at their edge being supported upon brickwork. Each pan has a discharge pipe, proceeding laterally from one side of its bottom, by which the melted metal may be run out when a plug is withdrawn, and each is heated by a small separate fire.

Three tons of the argentiferous lead constitute one charge of each pan; and as soon as it is melted, the fire is withdrawn; the flue, grate-door, and ash-pit, are immediately closed, and made air-tight with bricks and clay-lute. The agitation is now commenced, with a round bar of iron terminated with a chisel point, the workman being instructed merely to keep moving that simple rake constantly in the pan, but more especially towards the edges, where the solidification is apt to begin. He must be careful to take out the crystals, progressively as they appear, with an iron drainer, heated a little higher than the temperature of the metal bath. The liquid metal lifted in the drainer, flows readily back through its perforations, and may be at any rate effectually detached by giving the ladle two or three jogs. The solid portion remains in the form of a spongy, semi-crystalline, semi-pasty mass.

The proportion of crystals separated at each melting, depends upon the original quality of the alloy. If it be poor, it is usually divided in the proportion of two-thirds of poor crystals, and one-third of rich liquid metal; but this proportion is reversed if the alloy contain a good deal of silver.

Let us exemplify, by the common case of a lead containing 10 ounces of silver per ton. Operating upon three tons of this alloy, or 60 cwt., containing 30 oz. of silver, there will be obtained in the first operation —

| | |
|--|--------|
| (a) 40 cwt. at 4½ ounces of silver per ton; in whole 9 oz. } | 30 oz. |
| (b) 20 cwt. at 21 — — — — — 21 } | 21 |

Each of these alloys (a) and (b) will be joined to alloys of like quality obtained in the treatment of one or several other portions of three tons of the primitive alloy. Again, three tons of each of these rich alloys are subjected to the crystallization process, and thus in succession. Thus poorer and poorer lead is got on the one hand, and richer and richer alloys on the other. Sometimes the *mother* metal is parted from a great body of poor crystals, by opening the discharge-pipe, and running off the liquid, while the workman keeps stirring, to facilitate the separation of the two.

25 fadders, 15 cwt., 49 lbs. = 540 cwt., 49 lbs. of alloy, holding 5 oz. of silver per fadder, in the whole 130 oz., afforded, after three successive crystallisations —

| | |
|--|------------------|
| | oz. |
| 440 cwts. of poor lead, holding $\frac{1}{2}$ oz. of silver per fodder; in all | 10 $\frac{1}{2}$ |
| 15 cwt. 49 — holding the original quantity, nearly | 3 $\frac{1}{2}$ |
| 84 cwts. of lead for the cupel, holding 29 oz. | - 116 |
| Total - - - - - | - 130 |

1 cwt. of loss, principally in the reduction of dross.

The expenses of the new method altogether, including 3s. per fodder of patent dues, are about one-third of the old; being 17*l.* 13s. and 54*l.* 16s. respectively, upon 84 cwts. of lead, at 29 oz. per fodder.

In the conditions above stated, the treatment of argentiferous lead occasions the following expenses;—

| | FOR ONE FODDER. | £ | s. | d. |
|------------------------------|-----------------|---|----|----|
| By the new process - - - - - | - | 0 | 13 | 7 |
| old process - - - - - | - | 2 | 2 | 2 |

Admitting that the treatment of silver holding lead is economically possible only when the profit is equal to one-tenth of the gross expenses of the process, we may easily calculate, with the preceding data, that it is sufficient for the lead to have the following contents in silver:—

With the new process, 3 ounces per fodder; or, 0·000078

With the old process, 8 $\frac{1}{2}$ ounces per fodder; or, 0·000218

To conclude, the refining by crystallization reduces the cost of the parting of lead and silver, in the proportion of 3 to 1; and allows of extracting silver from a lead which contains only about 3 oz. per ton. In England, the new method produces at present very advantageous results, especially in reference to the great masses to which it may be applied. In 1828, the quantity of lead annually extracted from the mines in the United Kingdom had been progressively raised to 47,000 tons. Reduced almost to one-half of this amount in 1832, by the competition of the mines of la Sierra de Gador, the English production began again to increase in 1833. In 1835, 35,000 tons of lead were obtained, one-half of which only having a mean content of 8 $\frac{1}{2}$ oz. of silver per ton, was subjected to cupellation, and produced 14,000 oz. of that precious metal. The details of this production are—

| | |
|--|---------------|
| Silver extracted from 17,500 tons of lead, holding upon the average 8 $\frac{1}{2}$ oz. per ton. | } 140,000 oz. |
| Silver extracted from silver ores, properly so called, in Cornwall - - - | } 36,000 |
| | 176,000 |

See SMELTING OF LEAD.

In 1837, the production of lead amounted probably to 40,000 tons; upon which the introduction of the new method would have the effect not only of reducing considerably the cost of parting the 20,000 tons of lead containing 8 oz. of silver per ton, but of permitting the extraction of 4 or 5 oz. of silver, which may be supposed to exist upon an average in the greater portion of the remaining 20,000 tons. Otherwise, this mass of the precious metal would have had no value, or have been unproductive.

The desilverizing apparatus of Locke, Blacket and Co., consists of seven crystallizing pots, and one smaller pot for receiving the desilverized lead. They are all made of cast-iron, and arranged in a straight line.

The lead in each pot varies in its contents of silver.

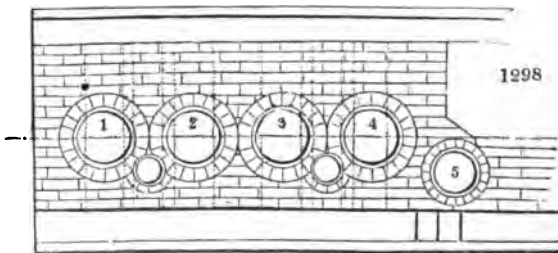
| | oz. | oz. |
|--|-----|-----|
| The first containing 85 cwt. lead at about 60 oz. of silver, or $\frac{1}{14}$ per ton | - | 255 |
| Is divided into 55 cwt. crystals carried to second pot, at 35 oz. per ton | - | 96 |
| 18 cwt. do. to be put in first pot again, at 64 oz. per ton | - | 57 |
| and 12 cwt. rich lead to be cupelled, at 170 oz. per ton - | - | 102 |
| | - | 255 |
| The second pot containing 90 cwt. lead, at about 35 oz. silver per ton | - | 157 |
| Is divided into 60 cwt. crystals carried to third pot, at 20 oz. per ton | - | 60 |
| and 30 cwt. lead put into first pot, at 65 oz. per ton - | - | 97 |
| | - | 157 |

| | | | |
|---|---|---|-------|
| The third pot containing 90 cwt. of lead, at about 20 oz. per ton | - | - | 90 |
| Is divided into 55 cwt. crystals, carried to fourth pot, at 10 oz. per ton | - | - | 27 |
| and 25 cwt. lead put into second pot, at 36 oz. per ton | - | - | 63 |
| | | | <hr/> |
| | | | 90 |
| The fourth pot containing 80 cwt. lead, at about 10 oz. per ton | - | - | 40 |
| Is divided into 55 cwt. crystals carried to fifth pot, at 5½ oz. per ton | - | - | 15 |
| and 25 cwt. lead put into third pot, at 20 oz. per ton | - | - | 25 |
| | | | <hr/> |
| | | | 40 |
| The fifth pot containing 80 cwt. lead, at about 5½ oz. silver per ton | - | - | 22 |
| Is divided into 55 cwt. crystals, put into sixth pot, at 3 oz. per ton | - | - | 8½ |
| and 25 cwt. lead, put into fourth pot, at 11 oz. per ton | - | - | 13½ |
| | | | <hr/> |
| | | | 22 |
| The sixth pot containing 80 cwt. lead, at about 3 oz. per ton | - | - | 12 |
| Is divided into 55 cwt. crystals, carried to seventh pot, at 1½ oz. per ton | - | - | 4½ |
| and 25 cwt. lead, put into fifth pot, at 6 oz. per ton | - | - | 7½ |
| | | | <hr/> |
| | | | 12 |
| The seventh pot containing 55 cwt. lead, at about 1½ oz. per ton | - | - | 4 |
| Is divided into 25 cwt. crystals carried to small pot, at ½ oz. per ton | - | - | ½ |
| and 30 cwt. lead, put into sixth pot, at 2½ oz. per ton | - | - | 3½ |
| | | | <hr/> |
| | | | 4 |

The above 25 cwt. of crystals are melted and cast into pigs and sent to market.

In operating upon lead containing about 10 oz. per ton, the fourth pot is filled with it; if it should contain 20 oz., or thereabouts, it is put in the third pot; and so of any other.

Fig. 1298, represents the arrangement of the iron pots or cauldrons, in their order.



The desilvering apparatus represented in *fig. 1298*, is composed of five cauldrons of cast iron, each heated by its own fire, besides two smaller pots, similarly heated. The cauldrons rest by their upper flange and surface upon bricks properly formed and arranged. Their shape is not hemispherical; their mouth is 40 inches in length, but only 26 inches in width. Over the door of the fireplace, the mouth stands 8 feet 4 inches above the ground or bottom of the ash-pit, of which space 18 inches intervene between the gate and the brim. The gate is 2 feet long and 8½ inches wide. All the cauldrons have the same elliptic form, with a bottom like the small end of an egg. The fifth alone is smaller, but this one serves merely to melt the lead which has been stripped of its silver, in order to be cast into salmons or blocks.

The charge consists of 64 or 65 salmons, each weighing from 120 to 140 lbs. When they are well melted, the fire is removed from the grate, as well as the small film of litharge from the surface of the metal; and one or two salmons are added to accelerate the cooling, or sometimes, instead, a little soapy water is sprinkled into the cauldron, whereby a crust of lead is formed, which being pushed down into the mass, melts with ebullition. This is repeated till the whole becomes sufficiently cool, that is, when crystals begin to form. The lead concreted round the sides being now detached, the whole is stirred with an iron bar, by a motion in a vertical plane, and varying its posture in this plane. During this operation, intended to establish a uniform temperature throughout the mass, a second workman heats in the smaller pot adjoining to No. 1. a large skimmer at the end of a long wooden handle, and next proceeds to fish out the crystals, taking care to let them drain off for a few seconds all the liquid lead among them, and then turns out the crystals slowly into the next cauldron, No. 2.: the second workman meanwhile adds the metal solidified round the sides, and stirs all together to equalise the temperature. These two-fold operations occupy about fifty

minutes; by which time, there remains in the cauldron about 16 salmons. The workman now lifts out the crystals, as before, with the drainer, and throws them upon the ground in two heaps. His assistant takes them up a little while afterwards, and puts them away to make room for fresh crystals, which the first workman continues to throw down. This process goes on till only 8 salmons remain in the cauldron, a point ascertained by gauging the height to the bath. The fire being at this time removed from cauldron No. 2. into the grate of No. 1. the 8 salmons of lead enriched with silver, which remain at the bottom of the cauldron, are run out into moveable moulds; and the 8 salmons which were thrown upon the ground are put into it; the full charge being then made up with salmons of the same richness as those previously used.

While this mass is melting in No. 1. the process just finished in it is repeated in No. 2. About three-fourths of the metallic mass is next separated in the state of crystals, which are transferred to No. 3. and also one-eighth of crystals thrown on the ground, after pouring the remaining one-eighth at the bottom of cauldron No. 2. not into moulds, but into No. 1.

A like process is performed in cauldrons 3. and 4.; and the poor lead taken out of 4. is transferred to 5. to be melted, and run into salmons, which are submitted afresh to the preceding series of crystallizations, provided the lead still contains a sufficient proportion of silver.

The following Table will place the results of the above successive operations in a clear light:—

| | | | | Silver in 1 Ton of lead. |
|------------------|---|---|---|--------------------------|
| Original lead | - | - | - | 0·001153 |
| 1. Rich crystals | - | - | - | 0·003324 |
| 2. Poor ditto | - | - | - | 0·000933 |
| — Rich ditto | } proceeding from the treatment of the preceding No. 2. poor crystals | - | - | 0·0020802 |
| 3. Poor ditto | | - | - | 0·0007021 |
| 4. Rich | } proceeding from the treatment of No. 3. poor crystals | - | - | 0·001399 |
| — Poor | | - | - | 0·0004569 |
| — Rich | } as above from No. 4. | - | - | 0·0008135 |
| (Lead) poor | | - | - | 0·0001128 |

We thus see, that four crystallizations, repeated upon the original lead from the smelting furnace, of the above richness, will afford a lead ten times poorer. With a lead originally containing only 0·0002248 in silver, three crystallizations would suffice to make it ten times poorer. In general, the poorer the lead, within certain limits, the better adapted is it to this process.

There are two oxides of silver; called argentic oxide, and suroside, by Berzelius.

1. The first is obtained by adding solution of caustic potassa, or lime-water, to a solution of nitrate of silver. The precipitate has a brownish-gray colour, which darkens when dried, and contains no combined water. Its specific gravity is 7·143. On exposure to the sun, it gives out a certain quantity of oxygen, and becomes a black powder. This oxide is an energetic base; being slightly soluble in pure water, reacting like the alkalis, upon reddened litmus paper, and displacing, from their combinations with the alkalis, a portion of the acids, with which it forms insoluble compounds. It is insoluble in the caustic lyes of potassa or soda. By combination with caustic ammonia, it forms *fulminating silver*. This formidable substance may be prepared by precipitating the nitrate of silver with lime-water, washing the oxide upon a filter, and spreading it upon gray paper, to make it nearly dry. Upon the oxide, still moist, water of ammonia is to be poured, and allowed to remain for several hours. The powder, which becomes black, is to be freed from the supernatant liquor by decantation, divided into small portions while moist, and set aside to dry upon bits of porous paper. Fulminating silver may be made more expeditiously by dissolving the nitrate in water of pure ammonia, and precipitating by the addition of caustic potassa lye in slight excess. If fulminating silver be pressed with a hard body in its moist state, it detonates with unparalleled violence; nay, when touched even with a feather, in its dry state, it frequently explodes. As many persons have been seriously wounded, and some have been killed, by these explosions, the utmost precautions should be taken, especially by young chemists, in its preparation. This violent phenomenon is caused by the sudden production of water and nitrogen, at the instant when the metallic oxide is reduced. The quiescent and divellent affinities seem to be so nicely balanced in this curious compound, that the slightest disturbance is sufficient to incite the hydrogen of the ammonia to snatch the oxygen from the silver. The oxide of silver dissolves in glassy fluxes, and renders them yellow. It consists, according to Berzelius, of 63·11 parts of silver, and 9·89 of oxygen.

2. The suroside of silver is obtained by passing a voltaic current through a weak solution of the nitrate; it being deposited, of course, at the positive or oxygenating pole. It is said to crystallize in needles of a metallic lustre, interlacing one another, which are

one-third of an inch long. When thrown into muriatic acid, it causes the disengagement of chlorine, and the formation of chloride of silver; into water of ammonia, it occasions such a rapid production of nitrogen gas, with a hissing sound, as to convert the whole liquid into froth. If a little of it, mixed with phosphorus, be struck with a hammer, a loud detonation ensues. With heat it decrepitates, and becomes metallic silver.

Sulphuret of silver, which exists native, may be readily prepared by fusing the constituents together; and it forms spontaneously upon the surface of silver exposed to the air of inhabited places, or plunged into eggs, especially rotten ones. The tarnish may be easily removed, by rubbing the metal with a solution of *cameleon mineral*, prepared by calcining peroxide of manganese with nitre. Sulphuret of silver is a powerful sulpho-base; since though it be heated to redness in close vessels, it retains the volatile sulphides, whose combinations with the alkalis are decomposed at that temperature. It consists of 87.04 of silver, and 12.96 of oxygen.

A small quantity of tin, alloyed with silver, destroys its ductility. The best method of separating these two metals, is to laminate the alloy into thin plates, and distil them along with corrosive sublimate. The bichloride of tin comes over in vapours, and condenses in the receiver. Silver and lead, when combined, are separated by heat alone in the process of cupellation, as described in the article *ASSAY*, and in the reduction of silver ores. See *suprd.*

An alloy, containing from one-twelfth to one-tenth of copper, constitutes the silver coin of most nations; being a harder and more durable metal under friction than pure silver. When this alloy is boiled with a solution of cream of tartar and sea-salt, or scrubbed with water of ammonia, the superficial particles of copper are removed, and a surface of fine silver is left.

Chloride of silver is obtained by adding muriatic acid, or any soluble muriate, to a solution of nitrate of silver. A curdy precipitate falls, quite insoluble in water, which being dried and heated to dull redness, fuses into a semi-transparent gray mass, called, from its appearance, *horn-silver*. Chloride of silver dissolves readily in water of ammonia, and crystallizes in proportion as the ammonia evaporates. It is not decomposed by a red heat, even when mixed with calcined charcoal; but when hydrogen or steam is passed over the fused chloride, muriatic acid exhales, and silver remains. When fused along with potassa (or its carbonate), the silver is also revived; while oxygen (or also carbonic acid) gas is liberated, and chloride of potassium is formed. Alkaline solutions do not decompose chloride of silver. When this compound is exposed to light, it suffers a partial decomposition, muriatic acid being disengaged. See *ASSAY* by the *humid method*.

The best way of reducing the chloride of silver, says Mohr, is to mix it with one-third of its weight of colophony (black rosin), and to heat the mixture moderately in a crucible till the flame ceases to have a greenish-blue colour; then suddenly to increase the fire, so as to melt the metal into an ingot.

The subchloride may be directly formed, by pouring a solution of deuto-chloride of copper or iron upon silver leaf. The metal is speedily changed into black spangles, which, being immediately washed and dried, constitute subchloride of silver. If the contact of the solutions be prolonged, chloride would be formed.

The bromide, cyanide, fluoride, and iodide of silver, have not been applied to any use in the arts. Sulphate of silver may be prepared by boiling sulphuric acid upon the metal. See *REFINING OF GOLD AND SILVER*. It dissolves in 88 parts of boiling water, but the greater part of the salt crystallizes in small needles as the solution cools. It consists of 118 parts of oxide, combined with 40 parts of dry acid. Solutions of the hyposulphite of potassa, soda, and lime, which are bitter salts, dissolve chloride of silver, a tasteless substance, into liquids possessed of the most palling sweetness, but not at all of any metallic taste.

The iodide of silver is remarkable, like some other metallic compounds, for changing its colour alternately with heat and cold. If a sheet of white paper be washed over with a solution of nitrate of silver, and afterwards with a somewhat dilute solution of hydriodate of potash, it will immediately assume the pale yellow tint of the cold silver iodide. On placing the paper before the fire, it will change colour from a pale primrose to a gaudy brilliant yellow, like the sun-flower; and on being cooled, it will again resume the primrose hue. These alternations may be repeated indefinitely, like those with the salts of cobalt, provided too great a heat be not applied. The pressure of a finger upon the hot yellow paper makes a white spot, by cooling it quickly.

Fulminate of silver is prepared in the same way as *FULMINATE of Mercury*, which see. On the 10th of February, 1798, the Lords of the Privy Council appointed the Hon. Charles Cavendish, F. R. S., and Charles Hatchett, Esq., F. R. S., to make investigations upon the wear of gold coin by friction. Their admirable experiments were begun in the latter end of 1798, and completed in April, 1801, having been instituted and con-

ducted with every mechanical aid, as devised by these most eminent chemical philosophers, and provided, at no small expense, by the government. The following are the important conclusions of their official report:—*

"Gold made standard by a mixture of equal parts of silver and copper, is not so soft as gold alloyed only with silver; neither is it so pale; for it appears to be less removed from the colour of fine gold, than either the former or the following metal.

"Gold, when alloyed with silver and copper, when annealed, does not become black, but brown; and this colour is more easily removed by the blanching liquor, or solution of alum, than when the whole of the alloy consists of copper. It may also be rolled and stamped with great facility; and, under many circumstances, it appears to suffer less by friction than gold alloyed by silver or copper alone.

"If copper alone forms the alloy, it must be dissolved and separated from the surface of each piece of coin, in the process of annealing and blanching.

"Upon a comparison of the different qualities of the three kinds of standard gold, it appears (strictly speaking) that gold made standard by silver and copper is rather to be preferred for coin."

It will, undoubtedly, seem not a little strange to the uninitiated, that this report, and its important deductions, should have been of late years entirely set at nought, without any scientific reason or research, apparently for the purpose of giving a certain official in our Mint a good job, in sweating out all the silver from our sovereigns, and replacing it, in the new coinage, with copper, taking on an average 3*d.* worth of silver out of each ounce of our excellent gold coin, and charging the country 6*d.* for its extraction, besides the very considerable expense in providing fine copper to replace the silver. The pretence set up for this extraordinary degradation of the gold, was, that our coin might peradventure be exported, in order to be de-silvered abroad, a danger which could have been most readily averted, by leaving out as much gold in every sovereign as was equivalent to the silver introduced, and thus preserving its intrinsic value in precious metal. When the film of fine gold which covers each of our present pieces has been rubbed off from the prominent parts, these must appear of a very different and deeper colour than the flat part or ground of the coin. "The reason, therefore, is sufficiently apparent," says Mr. Hatchett, "why gold which is alloyed with silver only, cannot be liable to this blemish;" and with one-half of silver alloy, it must be much less liable to it, than with copper alone. Why did the political economists in a late Committee of the House of Commons on the Mint blink this question of public economy and expediency?

Gold, as imported from America, Asia, and Africa, contains on an average nearly the right proportion of silver for making the best coin; and were it alloyed to our national standard, of 22 parts of gold, 1 of silver, and 1 of copper, as defined by Messrs. Cavendish and Hatchett, then by simply adding the deficient quantities of one or two of these metals, by the rule of alligation, the very considerable expense would be saved to the nation, and sulphureous nuisance to the Tower Hamlets, now foolishly incurred in de-silvering and cuprifying sovereigns at the Royal Mint.

It was long imagined in Europe, that the average metallic contents of the silver ores of Mexico and Peru were considerably greater than those of Saxony and Hungary. Much poorer ores, however, are worked among the Cordilleras than in any part of Europe. The mean products of the whole silver ores that are annually reduced in Mexico amounts only to from 0.18 to 0.25 of a per cent.: that is, from 3 to 4 ounces in 100 lbs.; the true average being, perhaps, not more than 2½. It is by their greater profusion of ores, not their superior richness, that the mines of South America surpass those of Europe.

Simple process for the reduction of silver to a metallic state by means of sugar. The silver of coin is first reduced to the state of chloride, and the weight of the alloy thus ascertained; the chloride, after having been well washed and freed from copper, is to be put into a stoppered wide necked bottle; a quantity of refined sugar, or sugar-candy, is then added, equal in weight to the alloy. This is mixed with an equal volume of a solution, composed of 60 grammes of good hydrate of potash, and 150 grammes of distilled water, which will yield solution of potash of 25° Baumé, or thereabouts: after closing the bottle the mixture is to be agitated, and then left for 24 hours, shaking it occasionally, to favour the reaction. After this period has elapsed, it is to be washed several times, until the last washings, filtered, are not affected by nitrate of silver, a test which should be preceded by that of red litmus paper, which ought not to become blue, or show any change whatever. This done, the contents of the bottle are to be transferred to a porcelain capsule, by the help of a little distilled water, then, after being allowed to deposit, the excess of liquid is poured off, and the silver dried in a stove.

By these means we obtain that which I have given the name of *grey silver*. This

* It is inserted in the *Philosophical Transactions* for 1803.

silver consists of some bright spangles, which become more brilliant on friction. It does not contain any impurities, with the exception of a small quantity of oxide, and a few atoms of chloride of silver. This latter produces a slight turbidity in the liquor, when dissolved in perfectly pure nitric acid, and diluted with distilled water. This turbidity does not, however, prevent the formation of pure nitrate of silver; as the chloride being only in suspension in the liquid, it is sufficient to filter it on a small portion of well washed asbestos, in order to obtain an unobjectionable liquor. The nitrate of silver will not contain any trace of other metals, as none are used in the reduction of the chloride of silver, and by the reduction of this salt, the silver is completely separated from the iron and copper which the solution might contain. Thus the nitric acid of commerce may be employed, without inconvenience, for dissolving the alloy.

The *grey silver* almost always contains a small quantity of oxide; this is easily verified by the addition of ammonia, which, after digestion on the metal and filtration, produces a slight turbidity on adding nitric acid, which is caused by the separation of the dissolved chloride of silver; the turbidity is then increased by the addition of a small quantity of chloride of sodium to the nitrate of ammonia previously formed; thus, then, is the oxide of silver dissolved in the liquor in the state of ammoniacal nitrate, which is precipitated in the form of insoluble chloride.

Oxide of silver not being an impurity in the uses to which pure silver is applied in laboratories, we may consider the *grey silver* obtained in the manner above described, as more pure, and with less loss, than any of those prepared up to the present time, by the reduction of chloride of silver; and without the necessity of melting, a troublesome operation, and one of much inconvenience in a laboratory.

From *una peseta* (one Spanish franc), the weight of which was 5·759 grammes, I obtained 4·750 grammes of *grey silver*, and supposing that the standard was at 90 per cent., which is doubtful, as the money of Seville has often an inferior standard, I obtained 91·6 per cent. of the silver contained in the alloy; but the remainder is not lost, as the waters of the washing acidulated by nitric acid are poured into the vessel on the precipitates of silver, and form a fresh chloride.

In making the mixture for the purpose of obtaining the *grey silver*, it will be observed that the substance, which, in the first instance is white, changes to a dirty, reddish-brown colour, afterwards to a violet-tinted grey; and, finally, to a blackish-brown. It then is to be left quiet for about half an hour, at the end of which time, the whole of the bottle will be found entirely covered with a thin layer of brilliant silver, forming a complete cylindrical mirror. This layer will remain as long as the liquid is not much shaken.

The white silver, of which I treat in the memoir from whence this note is extracted, is obtained by precipitating oxide of silver, and oxide of copper, by potash, then reducing oxide of silver by sugar, taking certain precautions; but, from the alloy only 46 per cent. of silver is obtained. In the state of dead silver, it is as white as pumice stone; and, by simple friction with a glass rod, it assumes considerable brilliancy. The white silver is free from oxide or chloride—it is *chemically pure*.

Production of silver in Spain, by Frederick Burr, Esq., Mining Engineer. In the earliest ages of authentic history, Spain was one of the countries most celebrated for the production of gold and silver, especially the latter. The Phœnicians and Carthaginians are said indeed to have freighted their ships with these metals, and even to have formed their anchors of them. On the subject of ancient mining in Spain a Spanish writer, Don Nicasio Anton Valle, states as follows, on the testimony of the classical authors. "The Emperor Vespasian obtained annually from Galicia, the Asturias and Lusitania, 60,000 lbs. of gold, as we are informed by Pliny, who extols the quantity of gold in these sites, particularly in the Asturias. The silver of Spain was found in such quantity that, according to the same author, Hannibal, in a mine worked by him near Cartagena, extracted daily a quantity which exceeded 30,000 reals (300*l.*) of our money. Cato delivered into the treasury 25,000 lbs. of silver in bars and 120,000 in money, besides 400 lbs. of gold, all of which he had accumulated in Spain. Helvetius, who was only governor of Andalusia, delivered 37,000 lbs. of silver in coin, and 40,000 lbs. of silver in bars."

On these ancient records of the production of the precious metals in Spain, I would remark that there is no reason to doubt their correctness, both from the result of modern discoveries of silver in that country, and the imperishable marks which Roman and Carthaginian mining has left there. I have seen with astonishment the vast excavations left by the ancients in the Sierra Almagrera and in the neighbourhood of Cartagena; while the enormous mounds of ancient scoria on the coast of the Mediterranean near the above localities, show the extent and activity with which metallurgical operations were carried on in the south of Spain. Within the last few years most of these mounds of ancient scoria have been re-smelted, and with considerable profit.

Passing from the time of the Romans, few records exist on the subject till the middle of the 16th century, when an attempt was made by Philip the Second to revive mining industry in Spain. The precious metals were, at this time, chiefly sought after, and the rich silver mines of Guadalcanal were discovered and worked in the Sierra Morena. Silver mines were also discovered at Cazalla, at Galeroa, and other places in the same range; these are described as being very rich at the time, but they all appear to have declined after a few years' working, and to have been abandoned about the end of the 16th or beginning of the 17th century. Of the mine of Guadalcanal very minute and authentic records were preserved during the period it was worked on account of the government. In these it is stated to have produced 400,223 marcs of silver in the first twenty years after its discovery, and while worked by the state. After this period it passed into the hands of the wealthy and celebrated family of the Fucarea, who are said to have obtained immense treasure from the mine previous to its being abandoned and filling with water.

It is only within the last 15 or 16 years that Spain has again become a silver producing country, several very rich mines of that metal having been discovered since the recent revival of mining, which dates back only from 1825. In 1839 the celebrated mines of the Sierra Almagrera, in the province of Almeria, were discovered, and they have ever since poured a large amount of silver annually into circulation.

In 1843, another great discovery of silver was made — the mines of Hiendelencina in the province of Guadalajara, which have since been very productive. Passing over more recent and minor discoveries, I may state that within the last few years the introduction of Mr. Pattinson's desilverizing process has been very general in the provinces of Murcia and Almeria. A large quantity of silver is thus annually obtained from the slightly argentiferous lead ores of the Sierra de Gador and of Cartagena, not formerly extracted, but which now contributes to swell the production of this metal in Spain.

The following is a statement of the quantity of silver produced in the mineral districts of the Sierra Almagrera and Murcia, during the years 1841—1847. As the quantity furnished by the province of Murcia, chiefly the mines of Mazarron, was inconsiderable, this statement may be looked upon as exhibiting very little more than the produce of the Sierra Almagrera — almost entirely obtained from the rich mines of the Barranco Jaroso.

| Years. | Silver, in marcs.* |
|---------------------------|--------------------|
| 1841 | 10,178 |
| 1842 | 56,675 |
| 1843 | 143,331 |
| 1844 | 159,285 |
| 1845 | 144,329 |
| 1846 | 135,141 |
| 1847 | 103,985 |
| Total in the seven years. | 752,926 marcs. |

Beyond the year 1847, I have not at hand any continuous statement of the produce of the mines of the Sierra Almagrera, but it is certain that their richness and production have declined considerably, partly on account of the lode becoming poorer below a certain level, and partly from having met with water in depth, since which the bottom galleries have necessarily been suspended. A steam-engine has however, at length, been erected in the Barranco Jaroso, and it is possible that discoveries may now be made in the bottom of the mine, which will again increase the extraction. The produce of the Almagrera mines in the year 1850 was 40,596 marcs of silver, and has probably since then remained about the same; for although the rich mines of the Jaroso have continued to decline, other discoveries have been made in the Sierra Almagrera, about two miles to the westward, which will have contributed to keep up the former production of silver.

Of the produce of the mines of Hiendelencina, I have not seen any statement, but although more uniform than that of the Sierra Almagrera, it has been considerably inferior to it.

The lodes of the Sierra Almagrera run nearly north and south, and traverse finely grained clay-slates and micaceous slates. The great lode of the Jaroso mines is of extraordinary size, being, in places, 6 or 8 yards, or even more in the width. The ores are chiefly argentiferous galena, the chloride of silver occurring but rarely, at least in a sepa-

* The ounces have been here omitted.

rate state. The lodes of Hiendelencina run nearly east and west; they seldom exceed 3 feet in width, and are properly *silver* lodes, as they produce the ores of silver, as chlorides and sulphurets, but unmixd with any ores of lead. The silver of the Sierra Almagrera has been almost entirely exported to Marseilles — that of Hiendelencina is sent to Madrid. The silver coinage of Spain has not been therefore by any means so considerable as might be inferred from her large production of that metal. It is stated, however, that in the year 1850, the total quantity of silver coined in Spain, in the three mints of Madrid, Barcelona, and Seville, amounted to the value of 97,780,919 reals, or, in round numbers, about 280,000*l.* sterling; the silver proceeded chiefly from the mines of Hiendelencina and Sierra Almagrera, exclusive of course of the bar silver which was exported.

Mr. B. H. Wilson, Consul for Peru, estimates the produce of the Peruvian mines at about 5,210,000 dollars a-year; about 3,500,000 dollars of this amount are exported on English, French, German, and Spanish account.

The whole annual production of Europe and Asiatic Russia, has been rated by Humboldt at 292,000 marcs; by other authorities, at 310,000; while at the beginning of the present century, that of the Spanish colonies in America was 3,349,160 marcs, or nearly twelve times as much. The sum total is 3,704,160 marcs, of 3609 grains troy each; which is nearly 1,900,000 lbs. avoirdupois; that is, little less than 9000 tons.

The whole of the mines of the Zmeingsorsk Circle have yielded an aggregate of 183,884,116 poods of ores, from which have been extracted 69,708 poods of silver, containing a quantity of gold estimated at 1,900 poods.

We are indebted for the following valuable tables to M. Michel Chevalier's *Remarks on the Production of the Precious Metals*, translated by D. Forbes Campbell, Esq.

Comparative Table, showing the annual Produce (approximate Calculation) in value of fine Gold and Silver, for 1846 and 1850, the former being Two Years before, the latter Two Years after the Discovery of the Gold Mines in California.

| | 1846. | | | 1850. | | |
|------------------------------------|-----------|-----------|------------|------------|-----------|------------|
| | Gold. | Silver. | Total. | Gold. | Silver. | Total. |
| | £ | £ | £ | £ | £ | £ |
| California - - - | - | - | - | 12,001,000 | 62,088 | 12,062,088 |
| United States - - | 237,336 | 1,864 | 239,200 | 115,430 | 11,444 | 126,874 |
| Mexico - - - - - | 249,753 | 3,457,020 | 3,706,773 | 382,901 | 5,383,333 | 5,766,234 |
| New Grenada - - - | 42,407 | 42,929 | 295,336 | 2,407 | 42,929 | 294,336 |
| Peru - - - - - | 96,241 | 1,000,583 | 1,096,824 | 96,241 | 1,000,583 | 1,096,824 |
| Bolivia - - - - - | 60,337 | 460,191 | 520,548 | 60,337 | 460,191 | 520,548 |
| Chili - - - - - | 145,585 | 297,029 | 442,614 | 145,585 | 297,029 | 442,614 |
| Brazil - - - - - | 259,871 | 2,003 | 261,874 | 289,068 | 3,227 | 291,295 |
| Total of North and South America - | 1,301,560 | 5,261,619 | 6,563,179 | 13,341,989 | 7,259,824 | 20,601,813 |
| Russia - - - - - | 3,414,427 | 167,831 | 3,582,258 | 4,175,860 | 171,817 | 4,347,477 |
| Norway - - - - - | - | 32,346 | 32,346 | - | 35,607 | 35,607 |
| North Germany - - | 357 | 138,022 | 138,379 | 357 | 138,022 | 138,379 |
| Saxony - - - - - | - | 198,200 | 198,200 | - | 198,200 | 198,200 |
| Austria - - - - - | 282,750 | 282,634 | 565,404 | 288,708 | 286,971 | 575,679 |
| Piedmont - - - - - | 17,841 | 7,444 | 25,285 | 17,841 | 7,444 | 25,285 |
| Spain - - - - - | 2,498 | 227,499 | 229,997 | 2,498 | 440,210 | 442,708 |
| United Kingdom - - | - | 119,989 | 109,989 | - | 160,000 | 160,000 |
| Africa - - - - - | 203,900 | 1,056 | 204,956 | 203,900 | 1,056 | 204,956 |
| Borneo - - - - - | 305,900 | 1,584 | 307,484 | 305,850 | 1,584 | 307,484 |
| Ava - - - - - | 100,000 | 617 | 100,617 | 100,000 | 617 | 100,617 |
| Malacca - - - - - | 72,240 | 374 | 72,614 | 72,240 | 374 | 72,614 |
| Sumatra - - - - - | 63,719 | 230 | 64,049 | 63,719 | 330 | 64,049 |
| Annam or Tonquin - | 30,585 | 53,460 | 84,045 | 30,585 | 53,460 | 84,045 |
| Various countries* | 50,975 | 33,000 | 83,975 | 50,975 | 33,000 | 83,975 |
| Total of Europe, Africa, and Asia | 4,545,192 | 1,254,306 | 5,799,498 | 5,312,583 | 1,528,599 | 6,840,975 |
| Total of North and South America - | 1,301,560 | 5,261,619 | 6,563,179 | 13,341,989 | 7,259,824 | 20,601,813 |
| Total - - - - - | 5,846,752 | 6,515,925 | 12,362,677 | 18,654,572 | 8,788,416 | 27,442,788 |

* Exclusive of China and Japan, which produce large quantities of gold and silver, the amount of which is quite unknown to Europeans.

NOTE. — At the beginning of the 19th century, Baron Humboldt's estimate (*Essai Politique*, tome II. p. 653) of the annual produce of North and South America was 17,291 kilogrammes=46,331 lbs. troy of gold, and 798,581 kilogrammes=2,181,770 lbs. of silver; value of both metals in dollars, 43,500,000=to 9,943,750*l.*; the produce of Europe and Northern Asia at the same time was 4,916 lbs. of gold, 250,593*l.*; and 199,296 lbs. silver, 657,683*l.* Total value of the precious metals raised in America, Europe, and Northern Asia, 10,152,026*l.*

The following table is similar to the above, with the exception that quantities are substituted for values.

| | 1846. | | 1850. | |
|--|----------------|------------------|----------------|------------------|
| | Pure Gold. | Pure Silver. | Pure Gold. | Pure Silver. |
| | Lbs. Troy. | Lbs. Troy. | Lbs. Troy. | Lbs. Troy. |
| * California - - - - - | - | - | 235,409 | 1,814 |
| United States - - - - - | 4,623 | 565 | 2,263 | 3,165 |
| Mexico:— In 1846, by the gold washings, 580 lbs. fine gold. | - | - | - | - |
| In 1846, by operation of parting, 3,920 lbs. fine gold. | 4,900 | 1,047,582 | 7,509 | 1,631,313 |
| New Grenada:— In 1846, by the English Colombian Gold Company, 343 lbs. fine gold | 4,954 | 13,009 | 4,954 | 13,009 |
| In 1850, by the English Marmato Gold Company, 376 lbs. fine gold, and 350 lbs. fine silver. | - | - | - | - |
| Peru - - - - - | 1,888 | 303,207 | 1,888 | 303,207 |
| Bolivia - - - - - | 1,184 | 139,472 | 1,184 | 139,432 |
| Chili, in 1850, by the English Copiapo Company, about 13 lbs. fine gold, and 7,000 lbs. fine silver. | 2,856 | 90,000 | 2,856 | 90,000 |
| * Brazil:— In 1846, by the English St. John d'el Rey Gold Company, 1425 lbs. gold, containing 20 per cent. silver. | - | - | - | - |
| 1850, by ditto, 2,517 lbs. gold, containing 20 per cent. silver. | - | - | - | - |
| 1846, by the English Imperial Brazilian Gold Company, 214 lbs. gold, containing about 14 per cent. silver. | 5,086 | 607 | 5,668 | 675 |
| 1850 by ditto, 379 lbs. gold, containing about 14 per cent. silver. | - | - | - | - |
| 1846, by the English National Brazilian Gold Company, 89 lbs. gold, containing about 14 per cent. silver. | - | - | - | - |
| 1850, by ditto, 190 lbs. gold, containing about 14 per cent. silver. | - | - | - | - |
| Total of North and South America - | 25,503 | 1,594,431 | 261,731 | 2,199,644 |
| Russia:— 1846, by private mines in the | | | | |
| Ural - - - - - 8,125 lbs. } 9 per cent. alloy } | 66,085 | 50,878 | 81,919 | 52,051 |
| Public ditto - - - - - 5,672 lbs. } | | | | |
| Private, Siberia - - - - - 57,235 lbs. } | | | | |
| Public ditto - - - - - 2,555 lbs. } | | | | |
| 73,587 lbs. | | | | |
| Norway (Kongsberg silver mines) - - - - - | - | 9,502 | - | 10,750 |
| North Germany (Hartz Mountains) - - - - - | 7 | 41,825 | 7 | 41,825 |
| Saxony - - - - - | - | 60,606 | - | 60,606 |
| Austria, in 1846, by private mines, about 4,100 lbs. pure gold, and 34,400 lbs. pure silver. By government mines, about 1,400 lbs. pure gold, and 51,200 lbs. pure silver - - - - - | 5,549 | 85,653 | 5,663 | 86,571 |
| Piedmont - - - - - | 350 | 2,256 | 350 | 2,256 |
| Spain - - - - - | 49 | 78,953 | 49 | 133,557 |
| United Kingdom - - - - - | - | 33,330 | - | 48,474 |
| * Africa - - - - - | 4,000 | 320 | 4,000 | 320 |
| * Borneo - - - - - | 6,000 | 480 | 6,000 | 480 |
| * Ava - - - - - | 1,261 | 157 | 1,261 | 157 |
| * Malacca - - - - - | 1,420 | 113 | 1,420 | 113 |
| * Sumatra - - - - - | 1,250 | 100 | 1,250 | 100 |
| Annan or Tonquin - - - - - | 600 | 16,200 | 600 | 16,200 |
| Various countries - - - - - | 1,000 | 10,000 | 1,000 | 10,000 |
| Total of Europe, Africa, and Asia - - - - - | 89,171 | 374,673 | 104,219 | 463,747 |
| Total of North and South America - - - - - | 25,503 | 1,794,431 | 261,731 | 2,199,644 |
| Grand Total - - - - - | 114,674 | 1,979,084 | 365,950 | 2,663,396 |

In 1801, the quantity of pure gold produced in America was 46,331 lbs.; in Europe and Northern Asia (exclusive of China and Japan), 4,916 lbs.; total produce, 51,247 lbs.=55,910 lbs. British standard gold =2,612,200.

In 1846, the quantity of pure gold produced in America was 25,503 lbs.; in Europe, Africa, and Asia (exclusive of China and Japan), 89,171 lbs.; total produce, 114,674 lbs.=126,108 lbs. British standard gold =5,846,772.

In 1850, the quantity of pure gold produced in America was 261,731 lbs.; in Europe, Africa, and Asia (exclusive of China and Japan), 101,219 lbs.; total produce, 365,950 lbs.=399,947 lbs. British standard gold =18,664,322.

* Those countries marked thus (*) have no silver mines at work; the silver stated is estimated as having existed in the native gold, to the average amount of 8 per cent.

Total Production of the Silver and Gold Mines of America prior to the Discovery of the Gold Mines of California.

| Countries. | Silver. | | Gold. | | Total for each Country in Millions of Francs. |
|---------------------|------------------------|------------------------------|------------------------|------------------------------|---|
| | Weight in Kilogrammes. | Value in Millions of Francs. | Weight in Kilogrammes. | Value in Millions of Francs. | |
| United States - - - | - | - | 22,125 | 76 | 76 |
| Mexico - - - | 61,985,522 | 13,774 | 389,269 | 1,341 | 15,115 |
| New Grenada - - - | 259,774 | 58 | 566,748 | 1,952 | 2,010 |
| Peru - - - | - | - | - | - | - |
| Bolivia } - - - | 58,766,244 | 13,059 | 240,393 | 1,172 | 14,231 |
| Brazil - - - | - | - | 1,242,300 | 4,623 | 4,623 |
| Chili - - - | 1,040,184 | 251 | 250,142 | 832 | 1,093 |
| Totals - - - | 122,050,724 | 27,122 | 2,940,977 | 10,026 | 37,148 |

Quantities of Gold and Silver supplied to the European Markets by the under-mentioned Countries during three Centuries ending in 1848.

| Countries. | Silver. | | Gold. | |
|---|------------------------|------------------------------|------------------------|------------------------------|
| | Weight in Kilogrammes. | Value in Millions of Francs. | Weight in Kilogrammes. | Value in Millions of Francs. |
| Europe, exclusive of Russia - - - | 9,000,000 | 2,000 | 445,150 | 1,560 |
| Russia - - - | 1,485,000 | 300 | 319,330 | 1,100 |
| Africa, and the Islands of the Malay Archipelago, &c. - - - | - | - | 725,750 | 2,500 |
| Totals - - - | 10,485,000 | 2,300 | 1,420,230 | 5,100 |

GOLD and SILVER produced in Forty Years, from 1790 to 1830.

| | Gold. | Silver. |
|--------------------|-----------|-------------|
| | £ | £ |
| Mexico - - - | 6,436,453 | 139,818,092 |
| Chile - - - | 2,768,488 | 1,822,924 |
| Buenos Ayres - - - | 4,024,895 | 27,182,673 |
| Russia - - - | 3,703,743 | 1,502,981 |

RETURNS of the DOLLARS coined at the different Mints in MEXICO.

| | 1829. | 1830. | 1831. | 1834. |
|-------------------|------------|------------|------------|------------|
| Mexico - - - | 1,280,000 | 1,090,000 | 1,386,000 | 952,000 |
| Guanajuata - - - | 2,406,000 | 2,560,000 | 2,603,000 | 2,703,000 |
| Zacatecas - - - | 4,505,000 | 5,190,000 | 4,965,000 | 5,527,000 |
| Guadalaxara - - - | 596,000 | 592,000 | 590,000 | 715,000 |
| Durango - - - | 659,000 | 453,000 | 358,000 | 1,215,000 |
| San Luis - - - | 1,613,000 | 1,320,000 | 1,497,000 | 928,000 |
| Ilalpan - - - | 728,000 | 90,000 | 323,000 | - |
| Total - - - | 11,787,000 | 11,295,000 | 11,722,000 | 12,040,000 |

The English Mint silver contains 222 pennyweights of fine silver, and 18 of copper, in the troy pound of 240 pennyweights; or 92.5 in 100 parts. 1 pound troy = 5760 grains, contains 65.8 shillings, each weighing 87.55 grains. The French silver coin contains one-

tenth of copper, and a franc weighs 5 grammes = 77.222 grains troy. The Prussian dollar (*thaler*), is the standard coin; 10½ *thaler* weigh 1 marc; hence 1 *thaler* weighs 343.7 grains troy, and contains 257.9 grains of fine silver; being 75 per cent. of silver, and 25 of alloy. The Austrian coin contains $\frac{1}{10}$ of alloy, according to Wasserburg; which is only 4½ per cent.

SILVER LEAF, is made in precisely the same way as *gold leaf*, to which article I must therefore refer the reader.

SILVERING, is the art of covering the surfaces of bodies with a thin film of silver. When silver leaf is to be applied, the methods prescribed for gold leaf are suitable. Among the metals, copper or brass are those on which the silverer most commonly operates. Iron is seldom silvered; but the processes for both metals are essentially the same. The white alloy of nickel is now often plated.

The principal steps of this operation are the following:—

1. The *smoothing down* the sharp edges, and polishing the surface of the copper; called *emorfler* by the French artists.

2. The *annealing*; or, making the piece to be silvered redhot, and then plunging it in very dilute nitric acid, till it be bright and clean.

3. *Pumicing*; or, clearing up the surface with pumice-stone and water.

4. The *warming*, to such a degree merely as, when it touches water, it may make a slight hissing sound; in which state it is dipped in the very weak aquafortis, whereby it acquires minute insensible asperities, sufficient to retain the silver leaves that are to be applied.

5. The *hatching*. When these small asperities are inadequate for giving due solidity to the silvering, the plane surfaces must be hatched all over with a graving tool; but the chased surfaces need not be touched.

6. The *bluing*, consists in heating the piece till its copper or brass colour changes to blue. In heating, they are placed in hot tools made of iron, called *mandrins* in France.

7. The *charging*, the workman's term for silvering. This operation consists in placing the silver leaves on the heated piece, and fixing them to its surface by burnishers of steel, of various forms. The workman begins by applying the leaves double. Should any part darken in the heating, it must be cleared up by the scratch-brush.

The silverer always works two pieces at once; so that he may heat the one, while burnishing the other. After applying two silver leaves, he must heat up the piece to the same degree, as at first, and he then fixes on with the burnisher four additional leaves of silver; and he goes on *charging* in the same way, 4 or 6 leaves at a time, till he has applied, one over another, 30, 40, 50, or 60 leaves, according to the desired solidity of the silvering. He then burnishes down with great pressure and address, till he has given the surface a uniform silvery aspect.

Silvering by the precipitated chloride of silver.—The white curd obtained by adding a solution of common salt to one of nitrate of silver is to be well washed and dried. One part of this powder is to be mixed with 3 parts of good pearlsh, one of washed whiting, and one and a half of sea salt. After clearing the surface of the brass, it is to be rubbed with a bit of soft leather, or cork moistened with water, and dipped in the above powder. After the silvering, it should be thoroughly washed with water, dried, and immediately varnished. Some use a mixture of 1 part of the silver precipitate, with 10 of cream of tartar, and this mixture also answers very well.

Others give a coating of silver by applying with friction, in the moistened state, a mixture of 1 part of silver-powder precipitated by copper, 2 parts of cream of tartar, and as much common salt. The piece must be immediately washed in tepid water very faintly alkalinized, then in slightly warm pure water, and finally wiped dry before the fire. See PLATED MANUFACTURE, and ELECTROTYPÉ.

The inferior kinds of plated buttons get their silver coating in the following way:—

2 ounces of chloride of silver are mixed up with 1 ounce of corrosive sublimate, 3 pounds of common salt, and 3 pounds of sulphate of zinc, with water, into a paste. The buttons being cleaned, are smeared over with that mixture, and exposed to a moderate degree of heat, which is eventually raised nearly to redness, so as to expel the mercury from the amalgam, formed by the reaction of the horn silver and the corrosive sublimate. The copper button thus acquires a silvery surface, which is brightened by clearing and burnishing.

Leather is silvered by applying a coat of parchment size, or spirit varnish, to the surface, and then the silver leaf, with pressure.

SILVERING OF GLASS. A coating of silver, not of tin amalgam as on common mirrors, is deposited on glass by the following process of Mr. Drayton. The plate being surrounded with a raised border of glazier's putty, is then covered with a solution of nitrate of silver, with which a little alcohol, water of ammonia, as also oils of cassia and clove, have been mixed. The silver is precipitated by the re-action of the alcohol and oils in a metallic state. This method will serve to silver small irregular and polygonal

surfaces of glass very conveniently; but the cost of the precious metal, &c. will preclude its application to large mirrors.

Mr. Drayton has patented a plan of making looking glasses and ornamental mirrors by coating glass with silver instead of mercury. He makes a mixture of nitrate of silver (1 oz.), with half an ounce of water of ammonia and 2 oz. of water, which after standing for 24 hours is filtered; (the deposit upon the filter, which is silver, being preserved), and an addition is made thereto of 3 oz. of spirit, (by preference of spirit of wine), at 60° above proof, or wood-spirit; from 20 to 30 drops of oil of cassia are then added, and after remaining for about 6 hours longer, the solution is ready for use. The glass to be silvered with this mixture must have a clean and polished surface; it is to be placed in a horizontal position, and a wall of putty or other suitable material formed round it; so that the solution may cover the surface of the glass, to the depth of from an eighth to a quarter of an inch. After the solution has been poured on the glass, from 6 to 12 drops of a mixture of oil of cloves and spirit of wine, (in the proportion of one part by measure of oil of cloves to three of spirit of wine), are dropped into it at different places, or the diluted oil of cloves may be mixed with the solution before it is poured on the glass; the more oil of cloves is used, the more rapid will be the decomposition of the silver, but it is preferable to effect it in 2 hours at soonest. When that has taken place, the solution is poured off, and as soon as the silver on the glass is quite dry, it is varnished with a composition formed by melting together equal parts of bee's wax and tallow. The solution after being poured off is allowed to stand for 3 or 4 days in a close vessel; as it still contains silver, it may again be employed after filtration, and the addition of a sufficient supply of fresh ingredients to replace those which have been used. The patentee states that he has found that about 18 grains of nitrate of silver are needed for each square foot of glass; but the quantity of spirit varies, from evaporation, with the temperature of the air and the duration of the process.

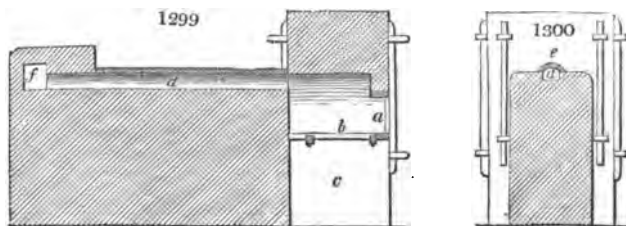
If the glass be placed in an inclined or even in a vertical position, and the surface covered over, leaving a narrow space for the solution between the surface of the glass and the cover which fits close, then by using spirit without water in the mixture, the object will be accomplished. The colour of the silver may be varied by adding a little oil of thyme or carui.

Oil of cassia varies much in quality as found in different shops; and if when mixed with the solution, it becomes flaky, the solution must be filtered before being applied to use.

SILVERSMITH'S STRIPPING LIQUID, consists of 8 parts of sulphuric acid and 1 part of nitre.

SIMILOR, is a golden-coloured variety of brass.

SINGEING OF WEBS. The old furnace for singeing cotton goods is represented in longitudinal section, *fig. 1299*, and in a transverse one in *fig. 1300*. *a* is the



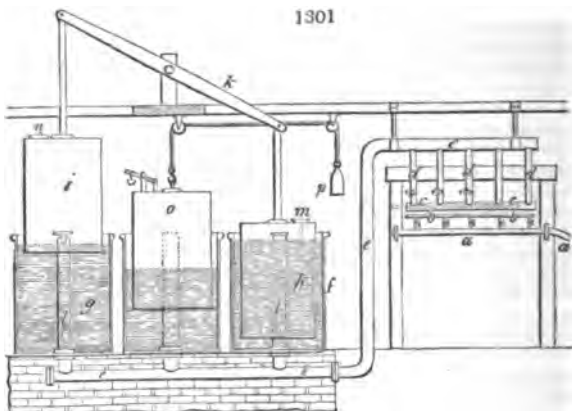
fire-door; *b*, the grate; *c*, the ashpit; *d*, a flue, 6 inches broad, and 2½ high, over which a hollow semi-cylindrical mass of cast-iron *a*, is laid, one inch thick at the sides, and 2½ thick at the top curvature. The flame passes along the fire flue *d*, into a side opening *f*, in the chimney. The goods are swept swiftly over this ignited piece of iron, with considerable friction, by means of a wooden roller, and a swing frame for raising them at any moment out of contact.

In some shops, semi-cylinders of copper, three quarters of an inch thick, have been substituted for those of iron, in singeing goods prior to bleaching them. The former last three months, and do 1500 pieces with one ton of coal; while the latter, which are an inch and a half thick, wear out in a week, and do no more than from 500 to 600 pieces with the same weight of fuel.

In the early part of the year 1818, Mr. Samuel Hall enrolled the specification of a patent for removing the downy fibres of the cotton thread from the interstices of bobbinet-lace, or muslins, which he effected by singeing the lace with the flame of a gas-

burner. The second patent granted to Mr. Hall, in April, 1823, is for an improvement in the above process; viz., causing a strong current of air to draw the flame of the gas through the interstices of the lace, as it passes over the burner, by means of an aperture in a tube placed immediately above the row of gas-jets, which tube communicates with an air-pump or exhauster.

Fig. 1301. shows the construction of the apparatus complete, and manner in which it operates; *a*, *a*, is a gas-pipe, supplied by an ordinary gasometer; from this pipe,



several small ones extend upwards to the long burner *b, b*. This burner is a horizontal tube, perforated with many small holes on the upper side, through which, as jets, the gas passes; and when it is ignited, the bobbinet lace, or other material intended to be singed, is extended and drawn rapidly over the flame, by means of rollers, which are not shown in the figure.

The simple burning of the gas, even with a draught chimney, as in the former specification, is found not to be at all times efficacious; the patentee, therefore, now introduces a hollow tube *c, c*, with a slit or opening, immediately over the row of burners; and this tube, by means of the pipes *d, d, d*, communicates with the pipe *e, e, e*, which leads to the exhausting apparatus.

This exhausting apparatus consists of two tanks, *f* and *g*, nearly filled with water, and two inverted boxes or vessels, *h* and *i*, which are suspended by rods to the vibrating beam *k*; each of the boxes is furnished with a valve opening upwards; *l, l*, are pipes extending from the horizontal part of the pipe *e*, up into the boxes or vessels *h* and *i*, which pipes have valves at their tops, also opening upward. When the vessel *h* descends, the water in the tank forces out the air contained within the vessel at the valve *m*; but when that vessel rises again, the valve *m* being closed, the air is drawn from the pipe *e*, through the pipe *l*. The same takes place in the vessel *i*, from which the air in its descent is expelled through the valve *n*, and in its ascent draws the air through the pipe *l*, from the pipe *e*. By these means, a partial exhaustion is effected in the pipe *e, e*, and the tube *c, c*; to supply which, the air rushes with considerable force through the long opening of the tube *c, c*, and carries with it the flame of the gas-burners. The bobbinet lace, or other goods, being now drawn over the flame between the burner *b, b*, and the exhausted tube *c, c*, by means of rollers, as above said, the flame of the gas is forced through the interstices of the fabric, and all the fine filaments and loose fibres of the thread are burnt off, without damaging the substance of the goods.

To adjust the draught from the gas-burners, there are stopcocks introduced into several of the pipes *d*; and to regulate the action of the exhausting apparatus, an air vessel *o* is suspended by a cord or chain passing over pulleys, and balanced by a weight *p*. There is also a scraper introduced into the tube *c*, which is made, by any convenient contrivance, to revolve and slide backwards and forwards, for the purpose of removing any light matter that may arise from the goods singed, and which would otherwise obstruct the air passage. Two of these draught tubes *c* may be adapted and united to the exhausting apparatus, when a double row of burners is employed, and the inclination of the flame may be directed upwards, downwards, or sideways, according to the position of the slit in the draught tube, by which means any description of goods may, if required, be singed on both sides at one operation.

The greater part of the bobbinet lace made in England is sent to Mr. Hall's works,

at Basford, near Nottingham, to be singed; and at a reduction of prices truly wonderful. He receives now only one farthing for what he originally was paid one shilling.

SIZING OF PAPER. See PAPER.

SKIN (*Peau*, Fr.; *Haut*, Germ.); the external membrane of animal bodies, consists of three layers: 1. the epidermis, scarf-skin, (*Oberhaut*, Germ.); 2. the vascular organ, or papillary body, which performs the secretions; and 3. the true skin, (*Lederhaut*, Germ.), of which leather is made. The skin proper, or dermoid substance, is a tissue of innumerable very delicate fibres, crossing each other in every possible direction, with small orifices between them, which are larger on its internal than on its external surface. The conical channels thus produced are not straight, but oblique, and filled with cellular membrane; they receive vessels and nerves which pass out through the skin (*cutis vera*), and are distributed upon the secretory organ. The fibrous texture of the skin is composed of the same animal matter as the serous membranes, the cartilages, and the cellular tissue; the whole possessing the property of dissolving in boiling water, and being, thereby, converted into glue. See GLUE, LEATHER, and TAN.

SLAG (*Laitier*, Fr.; *Schlacke*, Germ.); is the vitreous mass which covers the fused metal in the smelting-hearths. In the iron-works it is commonly called *cinder*. Slags consist, in general, of bi-silicates of lime and magnesia, along with the oxides of iron and other metals; being analogous in composition, and having the same crystalline form as the mineral *pyroxene*. See COPPER and IRON.

SLATES (*Ardoises*, Fr.; *Schiefern*, Germ.) The substances belonging to this class may be distributed into the following species:—

- | | |
|---|-----------------------------------|
| 1. Mica-slate, occasionally used for covering houses. | 5. Drawing-slate, or black chalk. |
| 2. Clay-slate, the proper roofing-slate. | 6. Adhesive slate. |
| 3. Whet-slate. | 7. Bituminous shale. |
| 4. Polishing-slate. | 8. Slate-clay. |

1. *Mica-slate*.—This is a mountain rock of vast continuity and extent, of a schistose texture, composed of the minerals mica and quartz, the mica being generally predominant.

2. *Clay-slate*.—This substance is closely connected with mica; so that uninterrupted transitions may be found between these two rocks in many mountain chains. It is a simple schistose mass, of a bluish-gray or grayish-black colour, of various shades, and a shining, somewhat pearly internal lustre on the faces, but of a dead colour in the cross fracture.

Clay-slate is extensively distributed in Great Britain. It skirts the Highlands of Scotland, from Lochlomond by Callender, Comrie, and Dunkeld; resting on, and gradually passing into mica-slate throughout the whole of that territory. Roofing-slate occurs on the western side of England, in the counties of Cornwall and Devon; in various parts of North Wales and Anglesea; in the north-east parts of Yorkshire, near Ingleton, and in Swaledale; as also in the counties of Cumberland and Westmorland. It is likewise met with in the counties of Wicklow and other mountainous districts of Ireland.

All the best beds of roofing-slate improve in quality as they lie deeper under the surface; near to which, indeed, they have little value.

A good roofing-slate should split readily into thin even laminæ; it should not be absorbent of water either on its face or endwise, a property evinced by its not increasing perceptibly in weight after immersion in water; and it should be sound, compact, and not apt to disintegrate in the air. The slate raised at Eisdale, on the west coast of Argyllshire, is very durable.

Cleaving and dressing of the slates.—The splitter begins by dividing the block, cut lengthwise, to a proper size, which he rests on end, and steadies between his knees. He uses a mallet and a chisel, which he introduces into the stone in a direction parallel to the *folia*. By this means he reduces it into several manageable pieces, and he gives to each the requisite length, by cutting cross grooves on the flat face, and then striking the slab with the chisel. It is afterwards split into thinner sections, by finer chisels dexterously applied to the edges. The slate is then dressed to the proper shape, by being laid on a block of wood, and having its projecting parts at the ends and sides cut off with a species of hatchet or chopping-knife. It deserves to be noticed that blocks of slate may lose their property of divisibility into thin laminæ. This happens from long exposure to the air, after they have been quarried. The workmen say, then, that they have lost their waters. For this reason, the number of splitters ought to be always proportioned to the number of block-bewers. Frost renders the blocks more fissile; but a supervening thaw renders them quite refractory. A new frost restores the faculty of splitting, though not to the same degree; and the workmen therefore avail themselves

of it without delay. A succession of frosts and thaws renders the quarried blocks quite intractable.

3. *Wet-slate, or Turkey hone*, is a slaty rock, containing a great proportion of quartz, in which the component particles, the same as in clay-slate and mica-slate, but in different proportions, are so very small as to be indiscernible.

4. *Polishing slate*. Colour, cream-yellow, in alternate stripes; massive; composition impalpable; principal fracture, slaty, thin and straight; cross fracture, fine earthy; feels fine, but meagre; adheres little, if at all, to the tongue; is very soft, passing into friable; specific gravity in the dry state, 0.6; when imbued with moisture, 1.9. It is supposed to have been formed from the ashes of burnt coal. It is found at Planitz, near Zwickau, and at Kutschlin near Bilin in Bohemia.

5. *Drawing-slate, or black chalk*; has a grayish-black colour; is very soft, sectile, easily broken, and adheres slightly to the tongue; spec. grav. 2.11. The streak is glistening. It occurs in beds in primitive and transition clay-slate; also in secondary formations, as in the coal-measures of most countries. It is used in crayon drawing. Its trace upon paper is regular and black. The best kinds are found in Spain, Italy, and France. Some good black chalk occurs also in Caernarvonshire and in the island of Islay.

6. *Adhesive slate*, has a light greenish-gray colour, is easily broken or exfoliated, has a shining streak, adheres strongly to the tongue, and absorbs water rapidly, with the emission of air-bubbles and a crackling sound.

7. *Bituminous shale*, is a species of soft, sectile slate-clay, much impregnated with bitumen, which occurs in the coal-measures.

8. *Slate-clay*, has a gray or grayish-yellow colour; is massive, with a dull glimmering lustre from spangles of mica interspersed. Its slaty fracture approaches at times to earthy; fragments, tabular; soft, sectile, and very frangible; specific gravity, 2.6. It adheres to the tongue, and crumbles down when immersed for some time in water. It is found as an alternating bed in the coal-measures. (See the sections of the strata under *PIR-COAL*.) When breathed upon, it emits a strong argillaceous odour. When free from lime and iron, it forms an excellent material for making refractory fire-bricks, being an infusible compound of alumina and silica; one of the best examples of which is the schist known by the name of *Stourbridge clay*.

SLIDES. The name given by the Cornish miners to clay veins of more modern formation.

SMALL WARES, is the name given in this country to textile articles of the tape kind, narrow windings of cotton, linen, silk, or woollen fabric; plaited sash cord, braid, &c. Tapes are woven upon a loom like that for weaving ribbons, which is now generally driven by mechanical power. Messrs. Worthington and Mulliner obtained a patent, in June, 1825, for improvements in such a loom, which have answered the purposes of their large factory in Manchester very well; and in May, 1831, Mr. Whitehead, of the same town, patented certain improvements in the manufacture of small wares. The objects of the latter patent are, the regular taking up of the tape or cloth, as it is woven, a greater facility of varying the vibration of the lay, together with the saving of room required for a range of looms to stand in.* See **BRAIDING MACHINE**.

SMALT, see **AZURE** and **COBALT**.

SMELTING, is the operation by which the ores of iron, copper, lead, &c., are reduced to the metallic state. See **METALLURGY, ORES**, and the respective metals.

Smelting of lead, by *H. L. Pattinson, Esq. F. R. S.*—The process of smelting may be most conveniently described under four heads, viz.:—

Roasting of the Ore.

Smelting in the Ore Hearth.

Smelting in the Slag Hearth.

Smelting of Hearth Ends and Smelters' Fume.

Roasting of the Ore.—The process of roasting is nothing more than heating the ore to a proper temperature in a reverberatory furnace, during which it undergoes a change, by the partial expulsion or acidification of the sulphur it contains, which renders it afterwards more easily reducible.

The manner of conducting the process of roasting is the same in all cases. The proper charge of ore is spread evenly over the bed of the furnace to the depth of two or three inches, and the fire is at first pushed moderately, during which the ore is frequently turned and stirred, in order that the whole may be uniformly heated, but care is to be taken that no part is prematurely fused. If the fire is judiciously managed, the charge gradually attains a dull red heat—a greater heat is then given, and the ore vigorously stirred, when, in a little time, it begins to feel soft and adhere slightly to the tool, in which state it is withdrawn from the furnace. The roasting process is conducted in the best manner, when great care is taken to apply the heat very gently at first, to keep, by

* *Newton's London Journal*, vol. xlii. p. 192; and vol. i. Combined Series, p. 212.

constant stirring and change of place, the temperature of the whole charge as uniform as possible, and to withdraw it at the proper time from the furnace.

After the furnace is properly heated and working, two Winchester bushels, or about $1\frac{1}{2}$ cwt. avoirdupois, of free coal, are required to roast one bing of ore; but some varieties of ore can be more easily reduced into the pasty state, mentioned above, than others; that is, they fuse at a lower degree of heat, and this in proportion to their purity. The least fusible ores are generally the most difficult to smelt, and undergo the greatest loss in that operation. It is well known that a considerably greater produce of lead can be obtained from the same ore after being properly roasted, than before. This difference is of course variable, but in some instances, 20 bings of roasted ore have yielded 8 or 9 cwt. more lead than 20 bings of the same ore smelted in its raw state.

At nearly all smelting mills long horizontal chimneys or flues are constructed (generally on the slope of an adjacent hill if practicable), which the smoke from the various processes of smelting is made to traverse before it escapes into the atmosphere. As the heat of the furnace in roasting, if incautiously applied, may volatilize a portion of the ore, and the draught has a tendency to draw along with it some of the smaller particles, the fume from the roasting furnace is conveyed into this flue, where the heavy metallic portion is deposited.

Smelting in the Ore Hearth.—The furnace in which the roasted ore is reduced into lead is called an ore hearth. Its construction is almost exactly the same in all smelting houses in the north of England, and seems to have undergone but little alteration from a very remote period. It may be briefly described as a square furnace, close on three of its sides, and open towards the bottom of the fourth. Immediately in front of this opening is placed a sloping cast-iron plate, the upper edge of which is $4\frac{1}{2}$ inches above the bottom of the furnace, forming a reservoir of that depth, in which the reduced lead accumulates, and out of which it flows, through a channel in the plate, into a pot below, after the reservoir becomes full.

In proceeding to smelt by means of an ore hearth, two workmen are required to be in attendance from the beginning to the end of each smelting shift, the duration of which is from 12 to 15 hours. The first step in commencing a smelting shift is to fill up the hearth-bottom, and space below the workstone with *peats*, placing one already kindled before the nozzle of the bellows. The powerful blast very soon sets the whole in a blaze, and by the addition of small quantities of coal at intervals, a body of fire is obtained filling the hearth. Roasted ore is now put upon the surface of the fire, between the fore-stone and pipestone, which immediately becomes heated red hot and reduced; the lead from it sinking down and collecting in the hearth bottom. Other portions of ore of 10 or 12 lbs. each are introduced from time to time, and the contents of the hearth are stirred and kept open, being occasionally drawn out and examined upon the workstone, until the hearth-bottom becomes full of lead. The hearth may now be considered in its regular working state, having a mass of heated fuel, mixed with partly fused and semi-reduced ore, called *Brouze*, floating upon a stratum of melted lead. The smelting shift is then regularly proceeded with by the two workmen, as follows:—The fire being made up, a stratum of ore is spread upon the horizontal surface of the *brouze*, and the whole suffered to remain exposed to the blast for the space of about five minutes. At the end of that time, one man plunges a poker into the fluid lead, in the hearth bottom below the *brouze*, and raises the whole up, at different places, so as to loosen and open the *brouze*, and in doing so, to pull a part of it forwards upon the workstone, allowing the recently added ore to sink down into the body of the hearth. The poker is now exchanged for a shovel, with a head 6 inches square, with which the *brouze* is examined upon the workstone, and any lumps that may have been too much fused, broken to pieces; those which are so far agglutinated by the heat, as to be quite hard, and further known by their brightness, being picked out, and thrown aside, to be afterwards smelted in the slag hearth. They are called "grey slags." A little slaked lime, in powder, is then spread upon the *brouze*, which has been drawn forward upon the workstone, if it exhibit a pasty appearance; and a portion of coal is added to the hearth, if necessary, which the workman knows by experience. In the mean time, his fellow workman, or shoulder fellow, clears the opening, through which the blast passes into the hearth, with a shovel, and places a peat immediately above it, which he holds in its proper situation, until it is fixed, by the return of all the *brouze*, from the workstone into the hearth. The fire is made up again into the shape before described, a stratum of fresh ore spread upon the part, and the operation of stirring, breaking the lumps upon the workstone, and picking out the hard slags repeated, after the expiration of a few minutes, exactly in the same manner. At every stirring a fresh peat is put above the nozzle of the bellows, which divides the blast, and causes it to be distributed all over the hearth; and as it burns away into light ashes, an opening is left for the blast to issue freely into the body of the *brouze*. The soft and porous nature of dried peat moss renders it very suitable for this purpose; but, in some instances, where a deficiency of peats has occurred, blocks of wood of the same size have been used with

little disadvantage As the smelting proceeds, the reduced lead, filtering down through all parts of the brouze into the hearth bottom, flows through the channel out of which it is laded into a proper mould, and formed into pigs.

The principal particulars to be attended to in managing an ore hearth properly, during the smelting shift, are these: First.—It is very important to employ a proper blast, which should be carefully regulated, so as to be neither too weak, nor too powerful. Too weak a blast would not excite the requisite heat to reduce the ore, and one too powerful has the effect of fusing the contents of the hearth into slags. In this particular no certain rules can be given; for the same blast is not suitable for every variety of ore. Soft free-grained galena, of great specific gravity, being very fusible, and easily reduced, requires a moderate blast; while the harder and lighter varieties, many of which contain more or less iron, and are often found rich in silver, require a blast considerably stronger. In all cases, it is most essential, that the blast should be no more than sufficient to reduce the ore, after every other necessary precaution is taken in working the hearth. Second.—The blast should be as much divided as possible, and made to pass through every part of the brouze. Third.—The hearth should be vigorously stirred, at due intervals, and part of its contents exposed upon the workstone; when the partially fused lumps should be well broken to pieces, and those which are further vitrified, so as to form slags, carefully picked out. This breaking to pieces, and exposure of the hottest part of the brouze upon the workstone, has a most beneficial effect in promoting its reduction into lead; for the atmospherical air immediately acts upon it, and, in that heated state, the sulphur is readily consumed, or converted into sulphureous acid, leaving the lead in its metallic state; hence it is that the reduced lead always flows most abundantly out of the hearth, immediately after the return of the brouze, which has been spread out and exposed to the atmosphere. Fourth.—The quantity of lime used should be no more than is just necessary to thicken the brouze sufficiently; as it does not, in the least, contribute to reduce the ore by any chemical effect: its use is merely to render the brouze less pasty, if from the heat being too great, or from the nature of the ore, it has a disposition to become very soft. Fifth.—Coal should be also supplied judiciously; too much unnecessarily increasing the bulk of the brouze, and causing the hearth to get too full.

When the ore is of a description to smelt readily, and the hearth is well managed in every particular, it works with but a small quantity of brouze, which feels dry when stirred, and is easily kept open and permeable to the blast. The reduction proceeds rapidly with a moderate degree of heat, and the slags produced are inconsiderable; but, if in this state, the stirring of the brouze and exposure upon the workstone are discontinued, or practised at longer intervals, the hearth quickly gets too hot, and immediately begins to agglutinate together; rendering evident the necessity of these operations to the successful management of the process. It is not difficult to understand why these effects take place, when it is considered, that in smelting by means of the ore hearth, it is the oxygen of the blast and the atmosphere which principally accomplishes the reduction; and the point to be chiefly attended to consists in exposing the ore to its action, at the proper temperature, and under the most favourable circumstances. The importance of having the ore free from impurities is also evident; for all the stony or earthy matter it contains impedes the smelting process, and increases the quantity of slags. A very slight difference of composition of perfectly dressed ore may readily be understood to affect its reducibility; and hence it is, that ore from different veins, or the same vein in different strata, as before observed, is frequently found to work very differently when smelted singly in the hearth. It happens, therefore, that with the best workmen, some varieties of ore require more coal and lime, and a greater degree of heat, than others; and it is for this reason that the forestone is made moveable, so as either to answer for ore which works with a large or a small quantity of brouze.

It has been stated that the duration of a smelting shift is from 12 to 15 hours, at the end of which time, with every precaution, the hearth is apt to become too hot, and it is necessary to stop for some time, in order that it may cool. At mills where the smelting shift is 12 hours, the hearths usually go on 12 hours, and are suspended 5; four and a half or five bings of ore (36 to 40 cwt.) are smelted during a shift, and the two men who manage the hearth, each work four shifts per week; terminating their week's work at 3 o'clock on Wednesday afternoon. They are succeeded by two other workmen, who also work four 12 hour shifts; the last of which they finish at 4 o'clock on Saturday. In these eight shifts, from 36 to 40 bings of ore are smelted, which, when of good quality, produce from 9 to 10 fadders of lead. At other mills where the shift is 14 or 15 hours, the furnace is kindled at 4 o'clock in the morning, and worked until 6 or 7 in the evening each day, six days in the week; during this shift, 5 or 5½ bings of ore are smelted, and two men at one hearth, in the early part of each week, work three such shifts, producing about 4 fadders of lead—two other men work each 3 shifts in the latter part of the week, making the total quantity smelted per week, in one hearth, from 30 to 33 bings. Almost at every smelting mill a different mode of working, in point of time,

and quantity, is pursued; in some cases the quantity of ore smelted in one hearth, in a week, by four men, is 40 bings; but a fair rate of working is from 30 to 35 bings per week.

The quantity of coal required to smelt a fodder of lead, as has been already stated, varies with the quality of the ore. When this latter is of moderate goodness, 8 Winchester bushels, or 6 cwt. avoidupois, are sufficient to smelt 18 or 20 bings; but, when the ore is refractory, the quantity required is very considerably greater. In general, from 8 to 12 Winchester bushels of coal, or from 6 to 9 cwt., are consumed during four smelting shifts of 12 hours each, and, as the quantity of lead made during this time is from $4\frac{1}{2}$ to 5 foders, the coal consumed is after the rate of from $1\frac{1}{2}$ to 2 cwt. per fodder. The quantity of peats used in the same time is about four small cart loads, being something less than a cart load per fodder of lead. The lime expended is about 12 Winchester bushels, or something below 3 bushels per fodder of lead.

Smelting in the Slag Hearth.—The slags picked out of the brouse during the process of ore hearth smelting are subjected to another operation, in what is called a slag hearth. It is simply a square furnace, open towards the bottom of the front side. Its dimensions are various, but a common size is 26 inches from back to front, 22 inches broad, and 36 inches deep, inside measure. The blast enters through the back wall, about 12 or 14 inches from the top, and below this, as the heat is inconsiderable, the sides of the furnace are usually made of cast iron (at working smelting-houses old bearers, or other worn parts of ore hearths, are economically used), but above the blast, where the heat is intense, the sides are formed of the most refractory firestone or firebrick. A cast-iron plate, 2 inches thick, placed at a slight slope outwards, forms the bottom of the hearth. A cast-iron pan, a peculiar form, is placed opposite to the opening in front, one lip of which is made to project inwards towards the furnace, and to extend a little below the sloping bottom of the hearth. This pan is divided with two compartments, by an iron partition, reaching nearly to its bottom, and is kept hot by a small fire underneath. Below the front of this pan, a square pit, 6 or 8 feet long, and 4 or 6 feet broad and deep, is dug. Pipes to convey water are laid to this pit, by which it can be kept constantly filled to within a few inches of the top, when the hearth is at work.

The only fuel used at the slag hearth is coke, and the method of working it is as follows:—

The larger division of the iron pan, and the whole space of the hearth below the orifice through which the blast enters, is filled with cinders of a moderate size, generally obtained from below the grate of an adjacent reverberatory furnace. Upon the top of these cinders, and opposite to the nozzle of the bellows, a kindled peat is placed, and the whole of the upper part of the hearth is filled with peat and coal, which is continually supplied, with the addition of coke as the fire gets hotter, until an intense heat is produced, and a body of fuel obtained, filling the upper part of the hearth. Some of the grey slags from the smelting hearth, unbroken, as picked out of the brouse, are now thrown upon the top, or rather round the edges of the fire, which fuses them rapidly into a liquid glass, and any lead they contain is set at liberty; the blast at the same time tending to reduce any particles of ore which may have escaped the action of the ore hearth. The lead and the melted glass both sink down through the porous mass of cinders placed in the lower part of the hearth; the lead descending more rapidly, both on account of its greater tenuity and superior specific gravity, very soon collects below the cinders, in the metal pan placed to receive it, and filtering through, is obtained without much impurity, out of which it is cast into pigs. The thick fluid glass, called black slag, after reaching the cast-iron bottom of the furnace, having cooled and thickened a little, does not sink further, but is made to issue through a small taphole, and flow over the cinders placed in the pan, running into the pit filled with water in a continued stream. By falling while hot into cold water, the black slag is granulated, and, as small particles of lead may be carried over with it, through inattention on the part of the workman, or otherwise, the granulated slags are carefully washed at most smelting mills before being thrown away. According to Dr. Thompson (*Ann. Phil.* vol. iv.) these slags consist of silex, lime, and oxide of iron, with some alumina, oxide of antimony, and oxide of lead. Their composition must, however, be various, depending upon the nature of the ore from which they are produced; in all cases they are formed from the earthy matter contained in the ore and coal, which the metallic oxides convert into a glass.

In working a slag hearth, the workman's attention is principally required to supply gray slag and fuel as it is melted down and consumed, to keep the nozzle of the bellows clear, and to guard against the metallic lead running along with the slag into the pit of water.

Two men are generally employed to work a slag hearth, but, at some mills, a man and a boy are deemed sufficient; the attention of one is wholly given to the fire, while the other supplies coke and gray slag. The length of a shift is 14 or 16 hours, during which

the quantity of lead made varies from 10 to 21 cwt., according to the nature of the slag. 20 to 24 bushels of coke are required to produce one fodder of lead. The quantity of slag lead made in smelting, as may be conceived, is considerably greater in poor and refractory than in rich and free-running ores, but, it may be stated generally at one-thirteenth of the lead yielded at the smelting hearth, so that it is usual to reckon, in large transactions, 13 twelve-stone pigs of common lead, and 1 of slag lead, to the fodder.

Hearth Ends and Smelter's Fume.—In the operation of smelting, as already described, it happens that particles of unreduced and semi-reduced ore are continually expelled from the hearth, partly by the force of the blast, but principally by the decrepitation of the ore on the application of heat. This ore is mixed with a portion of the fuel and lime made use of in smelting, all of which are deposited upon the top of the smelting hearth, and are called hearth-ends. It is customary to remove the hearth-ends from time to time, and deposit them in a convenient place until the end of the year, or some shorter period, when they are washed to get rid of the earthy matter they may contain, and the metallic portion is roasted at a strong heat, until it begins to soften and cohere into lumps, and afterwards smelted in the ore hearth, exactly in the same way as ore undergoing that operation, for the first time, already described.

It is difficult to state what quantity of hearth-ends are produced by the smelting of a given quantity of ore, but, in one instance, the hearth ends produced in smelting 9751 bings, on being roasted and reduced in the ore hearth, yielded of common lead 315 cwt., and the gray slags separated in this process gave, by treatment in the slag hearth, 47 cwt. of slag lead; making the total quantity of lead 362 cwt., which is at the rate of 3 cwt. 2 qrs. 23 lbs. from the smelting of 100 bings of ore.

The long horizontal chimneys, or flues, into which the smoke and metallic vapours, from the roasting furnace, ore hearth, and slag hearth, are conveyed, contain, at the end of some time, a copious deposit called smelter's fume. This fume consists of sulphuret, and, probably, also of sulphate of lead, which have been volatilized in the different processes, mixed, like hearth-ends, with a quantity of earthy matter, from the lime and coal used in smelting. It is generally suffered to accumulate, either in or out of the chimneys, until the end of the year, when it is washed, to remove the earthy matter, and the heavy residue is roasted until it coheres into lumps, and smelted in the slag hearth exactly in the same way as gray slags. The quantity of slag lead produced from the smelter's fume, deposited in smelting 9751 bings of ore, was 500 cwt.; being at the rate of 5 cwt. 0 qrs. 14 lbs. of lead per 100 bings of ore.

The proportions stated above are by no means to be considered invariable, for the quantity of lead produced at a smelting establishment, from time to time, by the hearth-ends and smelter's fume, from a given quantity of ore, cannot probably be very uniform, and must depend a good deal upon the care and skill exercised in conducting the various operations. If no more than the due degree of heat is used in each process, the deposits under consideration are likely to be less than if a strong heat is injudiciously applied.

Correspondence of Produce with Assay.—As the smelting process is liable to great mismanagement, through inexperience or inattention on the part of the agents or workmen, it is a matter of some consequence to know how far the quantity of lead obtained by smelting in the large way corresponds with the absolute quantity contained in the ore operated upon, and, for this purpose, it is a common practice to have the ore accurately sampled and assayed prior to smelting. The purest galena is a compound of

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|-----------------|---|---|---|----|---|---|---|-------|
| 1 atom lead, | - | - | - | 13 | - | - | - | 86.66 |
| 1 atom sulphur, | - | - | - | 2 | - | - | - | 13.33 |
| | | | | 15 | | | | 99.99 |

But this quantity of lead can never be obtained from it by assaying in the dry way. With great care, as far as 82 or 83 per cent. of lead may be obtained from a very pure piece of cubical galena, by treatment with borax and tartar, in the hands of an experienced assayer. In the large way lead ore is seldom dressed quite pure, and does not often yield more lead to the assay than 77 or 78 per cent. Ore, assayed to yield 77 per cent. of lead, contains, besides, probably, 4 or 5 per cent., which is oxidized, or volatilized, before reduction in the process of assaying. In estimating the value of a sample, reference is only made to its absolute produce by assay, no regard being paid to the probable quantity of lead it may contain beyond the assay produce.

It is never expected, in the large way, to obtain the quantity of metal indicated by the assay, but some ores in smelting approach much nearer to it than others. A customary allowance is to deduct 5 parts from the assay produce of 100 parts of ore, which is equivalent to making an allowance of 1 cwt. of lead for every ton of ore. Besides this, an allowance of 2 or 3 per cent., or more in wet weather, must be made for moisture in the

ore, when weighed over at the mine, as the sample assayed is, in all cases, perfectly dry. It is found, in practice, in almost every case where a large quantity of well-dressed ore is skilfully and carefully smelted, that the allowance of 5 parts of lead from the assay, or 1 cwt. of lead for every ton of ore, is rather more than sufficient to cover the loss in the smelting process, without taking into account the lead obtained from the hearths-ends and smelter's fume.

Refining of Lead.—The quantity of silver contained in the greater part of the lead raised in the northern mining district, is sufficient to render its extraction profitable, and it is of the greatest importance that the process of refining should be performed in the most perfect and economical manner, in consequence of the enormous quantity of lead continually submitted to this operation. It is well known that the separation of lead and silver is effected through the difference of oxidability between these two metals, silver remaining unaltered when exposed to the air of the atmosphere at a high temperature, and lead, under the same circumstances, becoming rapidly converted into the state of a protoxide; which, when formed in the large way, is called litharge. The refining process is therefore performed by exposing the lead containing silver to a strong blast of air, at a high temperature, in a furnace properly constructed to allow the litharge to separate as it is formed, and to admit of the continual introduction of lead as the operation proceeds, and the ready removal of the cake of silver obtained at the end of the process.

The furnace for this purpose is called a refining-furnace. It is a small reverberatory furnace, the fireplace of which is very large compared to the size of its body, rendering it capable of exciting an intense heat. Some of the objects to be attained in the construction of this furnace already stated, render it necessary that its bottom should be moveable, in consequence of which an open space is left quite through under the body of the furnace, from back to front, which is formed by two walls of brickwork. The distance of these walls in front is 36 inches; but they approach together at the back of the furnace, and the space between them is but 28 inches, which, to prevent a draught of cold air underneath the furnace bottom, is closed with iron doors. At the height of 16 or 17 inches from the floor two strong iron bars are laid across between these walls, and firmly secured in the brickwork at each end. Above these bars, and at the height of 27 inches from the floor, a plate of cast-iron, having an elliptical opening in the middle, the transverse and conjugate diameters of which are 46 and 28 inches respectively, is laid across, from wall to wall. Instead of a square plate, a broad elliptical ring, supported by bearers, is sometimes used; but, in either case, the brickwork forming the body of the furnace, is built upon this plate, and is made to extend to, and surround, the edge of the elliptical opening; except a small aperture in front, 6 inches wide by 9 inches high. The two flues communicate with the chimney, and in other respects, except those to be afterwards noticed, the furnace is finished in the usual manner.

The bed or bottom of the furnace, when in operation, is formed by a shallow elliptical vessel, called a *test* or *test-bottom*, the construction of which merits particular attention, as it is an important part of the refining apparatus. An elliptical iron ring, 4 feet long, 2 feet 6 inches broad, and 4 inches deep, outside measure. The thickness of the iron is $\frac{5}{8}$ of an inch, and across the bottom of the ring are five bars, each $3\frac{1}{2}$ or 4 inches broad, and $\frac{1}{2}$ an inch thick, firmly rivetted into the ring, with the under surface of each level with its lower edge. The ring is filled with a mixture of one part by measure of fern ashes, and ten parts of ground bone ashes, well incorporated and moistened with a little water, until a small quantity, when compressed in the hand, is found to cohere slightly together. In filling the test ring, it is placed upon a level floor, and this composition strongly beat into it, with an iron rammer 5 or 6 lbs. weight (similar to those used by foundrymen for compressing sand into moulds), until it is quite full, and the surface of the mixture perfectly level with the upper edge of the ring. A sharp spade is then taken, with which a part of the composition is removed, so as to form the test into a flat dish. The bottom of this dish is about $1\frac{1}{2}$ inch thick between the bars, and the breast of the test is 5 inches thick, the remainder of the circumference being 2 inches thick, and sloping inwards to increase its strength. Across the breast of the test, a furrow or small channel, called a *gateway*, is cut diagonally, 1 inch wide and $\frac{2}{3}$ of an inch deep, as a passage for the litharge; and it is made near one side of the breast, in order that a similar passage may be cut on the other side, after the test has been some time in operation, and the first gateway has become worn down by the stream of litharge. A space $1\frac{1}{2}$ inch wide, and 7 or 8 inches long, is cut out between the front of the breast and the test ring, in order that the litharge may flow down from the test, without coming in contact with the iron.

Instead of bone and fern ashes, mixed together in the proportions stated, it is a better practice, and one gradually coming into general use, to make the tests of a mixture of one part of the best American pearl ashes; to forty parts of bone ashes, by weight. The pearl ashes, reduced to fine powder, and perfectly dry, are thoroughly incorporated with

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ore, when weighed over at the mine, as the sample assayed is, in all cases, perfectly dry. It is found, in practice, in almost every case where a large quantity of well-dressed ore is skilfully and carefully smelted, that the allowance of 5 parts of lead from the assay, or 1 cwt. of lead for every ton of ore, is rather more than sufficient to cover the loss in the smelting process, without taking into account the lead obtained from the hearths-ends and smelter's fume.

Refining of Lead.— The quantity of silver contained in the greater part of the lead raised in the northern mining district, is sufficient to render its extraction profitable, and it is of the greatest importance that the process of refining should be performed in the most perfect and economical manner, in consequence of the enormous quantity of lead continually submitted to this operation. It is well known that the separation of lead and silver is effected through the difference of oxidability between these two metals, silver remaining unaltered when exposed to the air of the atmosphere at a high temperature, and lead, under the same circumstances, becoming rapidly converted into the state of a protoxide; which, when formed in the large way, is called litharge. The refining process is therefore performed by exposing the lead containing silver to a strong blast of air, at a high temperature, in a furnace properly constructed to allow the litharge to separate as it is formed, and to admit of the continual introduction of lead as the operation proceeds, and the ready removal of the cake of silver obtained at the end of the process.

The furnace for this purpose is called a refining-furnace. It is a small reverberatory furnace, the fireplace of which is very large compared to the size of its body, rendering it capable of exciting an intense heat. Some of the objects to be attained in the construction of this furnace already stated, render it necessary that its bottom should be moveable, in consequence of which an open space is left quite through under the body of the furnace, from back to front, which is formed by two walls of brickwork. The distance of these walls in front is 36 inches; but they approach together at the back of the furnace, and the space between them is but 28 inches, which, to prevent a draught of cold air underneath the furnace bottom, is closed with iron doors. At the height of 16 or 17 inches from the floor two strong iron bars are laid across between these walls, and firmly secured in the brickwork at each end. Above these bars, and at the height of 27 inches from the floor, a plate of cast-iron, having an elliptical opening in the middle, the transverse and conjugate diameters of which are 46 and 28 inches respectively, is laid across, from wall to wall. Instead of a square plate, a broad elliptical ring, supported by bearers, is sometimes used; but, in either case, the brickwork forming the body of the furnace, is built upon this plate, and is made to extend to, and surround, the edge of the elliptical opening; except a small aperture in front, 6 inches wide by 9 inches high. The two flues communicate with the chimney, and in other respects, except those to be afterwards noticed, the furnace is finished in the usual manner.

The bed or bottom of the furnace, when in operation, is formed by a shallow elliptical vessel, called a *test* or *test-bottom*, the construction of which merits particular attention, as it is an important part of the refining apparatus. An elliptical iron ring, 4 feet long, 2 feet 6 inches broad, and 4 inches deep, outside measure. The thickness of the iron is $\frac{1}{2}$ of an inch, and across the bottom of the ring are five bars, each $3\frac{1}{2}$ or 4 inches broad, and $\frac{1}{2}$ an inch thick, firmly rivetted into the ring, with the under surface of each level with its lower edge. The ring is filled with a mixture of one part by measure of fern ashes, and ten parts of ground bone ashes, well incorporated and moistened with a little water, until a small quantity, when compressed in the hand, is found to cohere slightly together. In filling the test ring, it is placed upon a level floor, and this composition strongly beat into it, with an iron rammer 5 or 6 lbs. weight (similar to those used by foundrymen for compressing sand into moulds), until it is quite full, and the surface of the mixture perfectly level with the upper edge of the ring. A sharp spade is then taken, with which a part of the composition is removed, so as to form the test into a flat dish. The bottom of this dish is about $1\frac{3}{4}$ inch thick between the bars, and the breast of the test is 5 inches thick, the remainder of the circumference being 2 inches thick, and sloping inwards to increase its strength. Across the breast of the test, a furrow or small channel, called a gateway, is cut diagonally, 1 inch wide and $\frac{3}{4}$ of an inch deep, as a passage for the litharge; and it is made near one side of the breast, in order that a similar passage may be cut on the other side, after the test has been some time in operation, and the first gateway has become worn down by the stream of litharge. A space $1\frac{1}{2}$ inch wide, and 7 or 8 inches long, is cut out between the front of the breast and the test ring, in order that the litharge may flow down from the test, without coming in contact with the iron.

Instead of bone and fern ashes, mixed together in the proportions stated, it is a better practice, and one gradually coming into general use, to make the tests of a mixture of one part of the best American pearl ashes, to forty parts of bone ashes, by weight. The pearl ashes, reduced to fine powder, and perfectly dry, are thoroughly incorporated with

the bone ashes, and the compound is then moistened to the proper degree with water after which the test ring is filled in the usual manner. From 4 to 5 pounds of pearl ashes are required for each test, the bone ashes for which weighs from 12 to 13 stones avoirdupois.

The test, thus constructed, is applied to the opening in the iron plate already described; the flat part of its circumference, being previously smeared over with a luting of bone ashes and water of the consistence of paste, and it is then firmly secured in its place by four iron wedges which rest upon the iron bars.

When the test is properly fixed in this situation, and thoroughly dried by the application of a gentle heat, it is ready for the reception of lead, which is poured into it, with an iron ladle, through the channel, being previously melted and kept nearly at a red heat in the pot. About 5 cwt. of lead is required to fill a new test to the working level. A mode of feeding the test is sometimes practised, which consists in suspending a pig of lead, or an iron weight, from a beam above the melting pot, by means of a chain, and allowing it to dip into the melted lead when made to descend, so as to force the lead displaced by its introduction directly into the test through the channel; which in that case must be a little lower than the lid of the melting pot. Some refining furnaces are not constructed with the channel; but, instead of it, having an opening in the brick-work of the furnace, on each side of the test, through one of which a whole pig of lead is introduced, and gradually melted down into the test by the heat of the fire; being pushed further in, from time to time, as the lead is consumed. An opening on each side of the test is considered necessary, in order that the lead may be always introduced, on the side opposite to the gateway working at the time, to prevent the possibility of its being carried by the stream of litharge over the breast of the test in its metallic state; and, in some instances, to be afterwards mentioned, where so large a quantity of lead is refined in a test, as to render it necessary to have three gateways, the lead is introduced through an opening behind, during the time that the middle gateway is at work.

The last part of the refining furnace to be noticed is the aperture behind, for the admission of a current of air, supplied by a powerful double bellows, worked by machinery. This aperture is formed by a conical iron tube called a muzzle, walled into the brickwork forming the back of the furnace; its larger end outwards, receives the nozzle of the bellows, and its smaller end projecting into the furnace, over the inner edge of the test, is bent down slightly, and its orifice compressed into an oval form, so as to deliver the blast with sufficient force upon the surface of the lead, and at the same time to spread it out towards the sides of the test. Much care is usually bestowed upon the construction of the muzzle, as the proper direction and distribution of the blast, is a point of great consequence to the working of the furnace.

Refining furnaces are generally built double, that is one on each side of the upright chimney; but, excepting in the direction of the draught, and consequent situation of the fire-places, there is no difference whatever between them. The fume and smoke from both are conveyed into a division of the horizontal flue, separate from that containing the smoke from the roasting furnace, ore hearth, and slag hearth, with which they are not suffered to mix. Here they deposit a heavy gray powder, called refiner's fume, which is principally oxide of lead.

The test being properly placed in its situation, cautiously dried, and filled with lead as already detailed, is exposed with its contents to the flame passing over it, until the lead attains a bright red heat, at which period the blast of air is made to play upon its surface. The oxygen thus supplied rapidly produces a stratum of fluid litharge, which is propelled forwards by the blast, and forced through the gateway, over the breast of the test; its place being supplied by a fresh quantity, so as to keep up a continual stream. The litharge concretes into lumps as it falls, which are removed from time to time by the workmen in attendance, who take care, by the addition of fresh quantities of lead, to keep its surface in the test always at the proper working level. In this way the operation proceeds; but as the hot litharge gradually wears down the gateway, so as to render the test incapable of holding a sufficient quantity of lead, it becomes necessary to make a fresh gateway, generally after two fadders of lead have been refined. When this is done, the blast is suspended, the old gateway is stopped up with a paste of bone ashes, a fresh channel made on the other side of the breast, and the test filled up with lead to the proper level, as at first. The process then proceeds again, until two fadders more of lead have been oxidised, when the second gateway being also worn down, until the test does not contain more than one cwt. of lead, the wedges supporting it behind are slackened, and those in front taken away, and the fluid lead, called technically rich lead, is poured into an iron pot 18 inches in diameter, running upon a carriage with four wheels. This rich lead, containing the silver of four fadders of original lead (usually from 30 to 40 oz.) is cast into a pig and taken away: a fresh test is applied to the furnace, and 4 fadders of lead worked in it, in the manner described, until 50 or 60

pieces of rich lead are obtained. A test is then made, the bottom of which is somewhat concave, instead of being flat like those already mentioned, and in this the rich lead is carefully refined, yielding, at the end of the process, a cake of silver weighing from 1200 to 1800 ounces. The rich lead is treated in the same way as ordinary lead, except perhaps more carefully, and after the last piece is introduced, the gateway is made deeper with an iron tool, from time to time, as the surface of the lead subsides by its gradual conversion into litharge; and, from this period until the cake of silver is rendered pure, all the litharge then flowing is kept separate, as it is apt to carry along with it a portion of silver. The part received is called rich litharge, and may contain on an average 20 oz. of silver per ton; it is generally worked up at the end of the year, by being reduced into lead and again refined. As the cake of silver becomes nearly pure, it is most essential to keep it constantly in fusion, for, if once suffered to solidify, it is very difficult to excite a sufficient heat to melt it again. The fire is therefore urged with great violence, until at length the whole of the lead being oxidized, the formation of litharge ceases, and the mass of melted silver appears pure and beautifully replenished. At this stage, it sometimes happens that drops of melted slag from the furnace roof fall down upon the fluid silver, in which case they are carefully brought to the edge of the melted metal, and raked off upon the naked part of the test. The blast from the bellows is now stopped, the fire is slacked, and the silver suffered to cool; which it does, very gradually, first at the surface, forming a solid crust over, a portion remaining fluid below. When the temperature has fallen sufficiently, this also becomes solid, and in the act of doing so, a large quantity of nearly pure oxygen gas is expelled from it, and at the same instant its particles expand considerably, so as to break the crust already formed, and force out a portion of silver, to the height of 3 or 4 inches above the rest of the cake. Occasionally particles of melted silver are projected out of this mass, to a distance over the naked part of the test, and the sides of the furnace, by which a loss of the precious metal is sometimes sustained. After having cooled sufficiently, the cake of silver is removed from the furnace along with the test, from which it is then separated without difficulty; and if any slag or portions of the test are found to adhere to it, they are cleaned off, and it is ready for sale.

During the working of each test it gradually absorbs litharge until saturated, and the portion thus combined is sufficient to pay the cost of extraction. For this purpose, the old tests are broken to pieces, and smelted in the slag hearth, mixed with a portion of black slag, in order to render the bone ashes more fusible; the black slag used being run into lumps for the purpose, and not granulated in the ordinary way. The produce of this fusion is a description of lead called test-bottom lead, which is very hard, and of inferior quality.

The deposit called refiner's fume is removed from the horizontal flues from time to time, and is frequently ground up with oil, forming a very cheap and durable paint; but the quantity produced is generally too considerable to admit of the whole being disposed of in this way, and the surplus is reduced by being roasted almost to fusion, and then worked in the slag hearth, in the same manner as gray slags. As might be expected, the lead obtained from the test bottoms and refiner's fume contains but a very small portion of silver.

Instead of converting into litharge but 4 fadders of lead in each test, as already mentioned, some refiners are in the habit of working 12 or 13; but, in this case, the tests are constructed with peculiar care, and the bottom, sides, and breasts are made thicker than usual. The litharge from 4 fadders of lead flows through the first gateway made on one side of the breast, and when the quantity of lead in the test is reduced to about a cwt., it is cast into a rich pig: 4 fadders of lead are then worked through another gateway, on the opposite side of the breast, yielding a pig of rich lead in the same manner; and, for the remaining 4 fadders, a gateway is made across the middle of the breast. By adopting this method of working, the loss from the lead absorbed by the test bottoms is considerably lessened, and a great saving is made in the expense of tests; but the process is rendered slower, as it is necessary to work at a low degree of heat. The saving in tests is not what it appears to be at first sight; for those made to refine the larger quantity of lead, being thicker and stronger than the others, require a larger quantity of bone ashes.

The rate of refining varies a little, from the cause just stated. When 4 fadders of lead are oxidised in a test, it is usual to accomplish this in from 16 to 18 hours; and 6 tests, or 24 fadders of lead, can be very easily converted into litharge, in one furnace, by 3 men in a week. The quantity of coal consumed is about 4 Winchester bushels, or 3 cwt. avordupois, per fodder of lead. In cases where 12 or 13 fadders of lead are refined in a test, it is customary to work but one test in a week, in one furnace, which is only half the quantity stated above; but here also, three men by managing 2 furnaces refine 24 to 26 fadders of lead per week.

Reducing of Litharge.—The reduction of litharge into lead is an easy process, and, in

the great way, is very expeditiously performed, in a reverberatory furnace almost exactly similar to the roasting furnace already described, except that its bed or bottom, instead of being flat, is made to slope towards an opening in the side, through which the reduced lead is conveyed, by means of a cast-iron channel, into a pot, to be finally made into pigs for sale. The inside of a roasting furnace is generally made somewhat elliptical, about 6 feet long, and $5\frac{1}{2}$ broad, and a furnace of this size, worked by three men, at 8 hours shifts each, is capable of reducing, without difficulty, all the lead oxidized in two refining furnaces, each working six tests, or 24 fadders per week. After the reducing furnace has been properly heated, the process is commenced by covering its bottom with a stratum of coal, which taking fire, very soon forms a mass of ignited fuel some inches in thickness. Upon this the charge of litharge mixed up with a small quantity of fresh coal is thrown, and a furnace of the size mentioned will hold from two to three tons. The reduction goes on rapidly, and the furnace is supplied, from time to time, with fresh litharge, until the quantity added is such as will produce from 4 to 5 fadders of lead; the charge is then suffered to run down, with the addition of fresh coal, to promote the reduction, as it seems to be required. At the end of nine or ten hours, the whole of the litharge is reduced, and, at the bottom of the furnace, there remains only a portion of slag, called litharge slag, which is raked out while still hot to prepare for the next charge.

This litharge slag is formed by the vitrification of the earthy matter contained in the coal used in reduction, and, as a small quantity of lead is unavoidably united with it, it is afterwards worked over in the slag-heap with black slag, in the same way as the test-bottoms, yielding what is called litharge slag lead, which, like test-bottom lead, is of inferior quality and contains little silver. It is of importance that the best coal should be used to mix with the litharge, in order that the slag formed may be as little as possible. The coal required for reducing is about $4\frac{1}{2}$ Winchester bushels, or near $3\frac{1}{2}$ cwt. per fodder of lead reduced, including the quantity mixed with the litharge.

The quantity of test-bottom and litharge slag lead made in refining may be variable; but, in several cases which have come under the writer's notice, they have, together, amounted to one thirty-second part of the original lead refined.

The produce of lead from the refiner's fume has appeared to be, in the only case submitted to the writer's consideration, about 1 per cent. on the total quantity of lead undergoing the refining process; but this deposit must be very much modified, like the hearth ends and smelter's fume, by the degree of heat at which the refining furnaces are worked; it is therefore impossible, perhaps, to make a statement which will exactly correspond with experience at every smelting establishment.

Correspondence of the Produce of Silver with the Assay, and loss of Lead in the Process of Refining. — The practice is very general of assaying the lead to be refined previous to the process, by taking a chip from each pig, melting the whole together, and submitting a known weight to cupellation. It frequently happens that the quantity of silver obtained in the large way is greater than that indicated by the assay, the reason of which is, that the litharge, as it sinks into the small cupel, carries with it a minute portion of silver, rendering the button obtained rather less than it ought to be; but by reducing the litharge absorbed by the small cupel back into lead, with black flux and borax, and refining this lead a second time, another minute button of silver is obtained, which added to the first button, generally indicates a quantity of silver in the lead under examination, with which its produce in the great way, when carefully refined, very closely coincides, taking into account the small portion of silver unavoidably carried over with the litharge, and found in all samples of refined lead, to the extent of from half an ounce to an ounce per fodder. It will easily be conceived that if the small process of cupellation has been carefully performed at first, with a due degree of heat and in a good cupel, the second button of silver will be exceedingly small, and that it will be larger as these particulars have not been attended to.

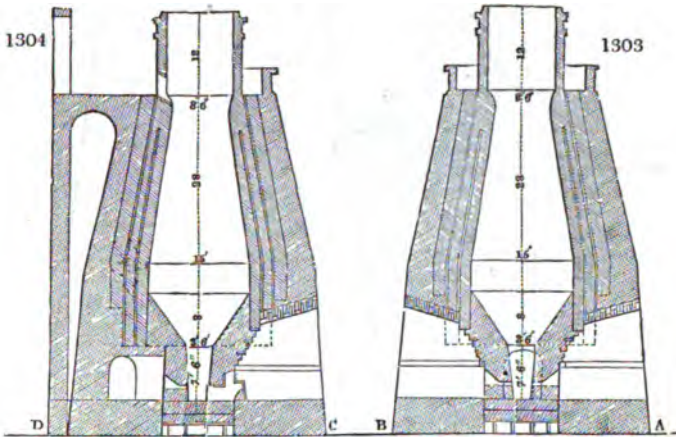
Where assays of lead ore, for lead and silver, have been extensively made, to determine the quantity of both metals which should be obtained from the ore by melting and refining, the produce in the large way has been found in most instances very nearly to correspond with the assay, after making an allowance on the lead of 5 parts from the assay, or 1 cwt. of lead for every ton of ore, and multiplying the quantity of lead indicated after this allowance, by the proportion of silver carefully determined by the assay. For figures, see LEAD.

The loss of lead in the refining and reducing processes is usually estimated, in the first instance, at one-twelfth of the quantity refined; but, when the deposit of refiner's fume is melted up, and the lead extracted from the test-bottoms and litharge slag, the ultimate loss becomes not more than one-fifteenth, and with some smelters one-sixteenth of the original quantity. The loss sustained is least when the refining furnace is worked at a low temperature, but it is not expedient to reduce the test to the lowest degree of heat at which the oxidation will go on, for, in this case, the litharge, at the moment of

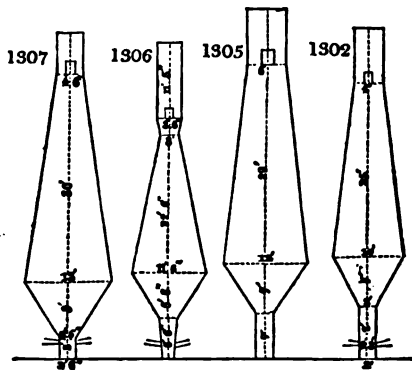
its formation, is not sufficiently fluid to allow the particles of silver to separate from it, and combine with the remaining lead in the cupel; they are thus, as it were, entangled in the litharge, and carried with it over the breast, by which the produce of silver is materially diminished.

SMELTING IRON FURNACES, commonly called **BLAST FURNACES**. Several of these furnaces, as mounted near Glasgow, deserve to be made known, on account of the economy of their construction, the advantage of their form, and the amount of their performance.

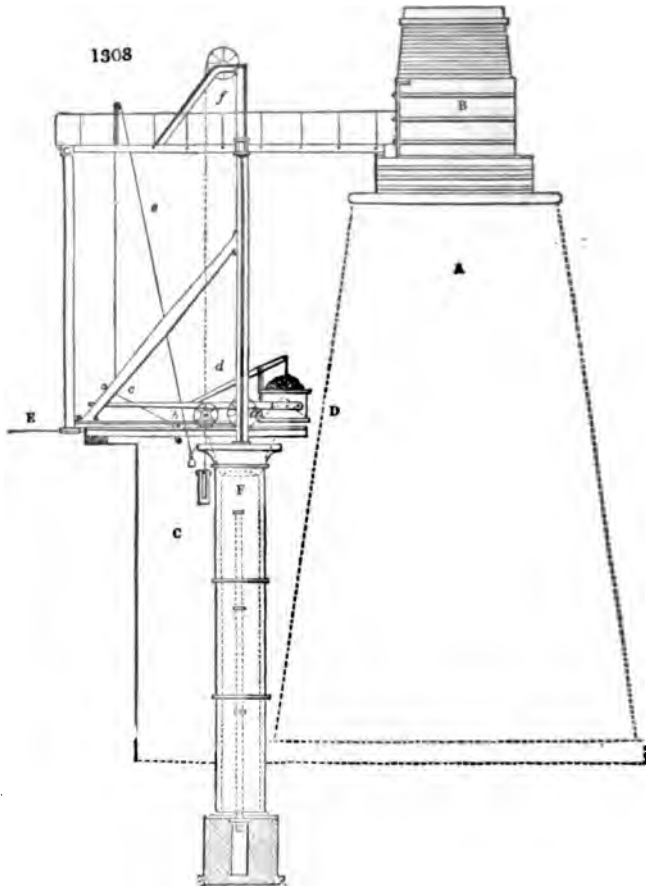
Fig. 1302. represents one of the smallest of these, which measures from the line at the bottom to the top 48 feet, from which all the other dimensions may be estimated. It produces a soft cast-iron for casting into moulds and for melting in the cupola. *Figs. 1303, & 1304.* represent a much larger furnace, being from the top to the line *a, b, c, d,*



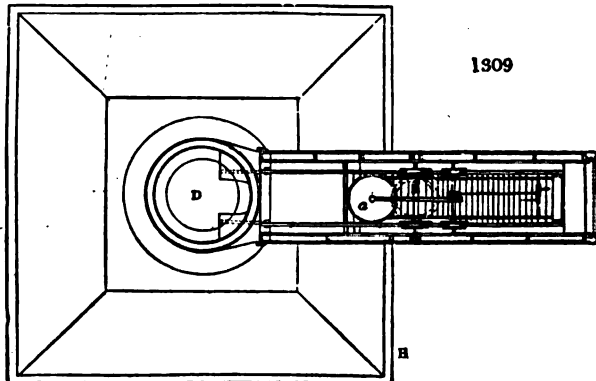
60 feet high. A few have been built still larger. This furnace has a double case, each of which consists of fire-bricks. This case is enclosed by common bricks, and these by a wall of stone masonry. The successive rows of bricks are laid stair-wise, having the angular retreat filled up with fire-clay. *Fig. 1307.* is a modern furnace of very large dimensions, as the numbers upon it show.



William Jessop, Esquire, of the great iron works of Butterly and Codner Park in Derbyshire, has invented a very elegant and effective apparatus for feeding his blast furnaces with fuel, *mise* (calcined ironstone), and limestone in due proportions, and equally distributed round the inside of the furnace. *Figs. 1308, 09.* represent this feed-apparatus. *Fig. 1308.* shows at *a* an outline of the furnace, and at *b*, the line of entrance into its throat. *c*, is the feed mechanism. It consists of a long balance lever barrow, *d, e*; *n*, being an iron cylinder, open at top and bottom, 4 feet in diameter and 2½ feet in height, in the inside of which a hollow cone of iron is suspended, with



its apex uppermost, so that while the base of the cone is kept above the level of the bottom of the cylinder it shuts it; but on the cone being lowered below that level, it allows the charge of materials resting all round on the slant surface of the cone to fall down equally round the side of the cylinder into the furnace. In *fig.* 1309, the barrow

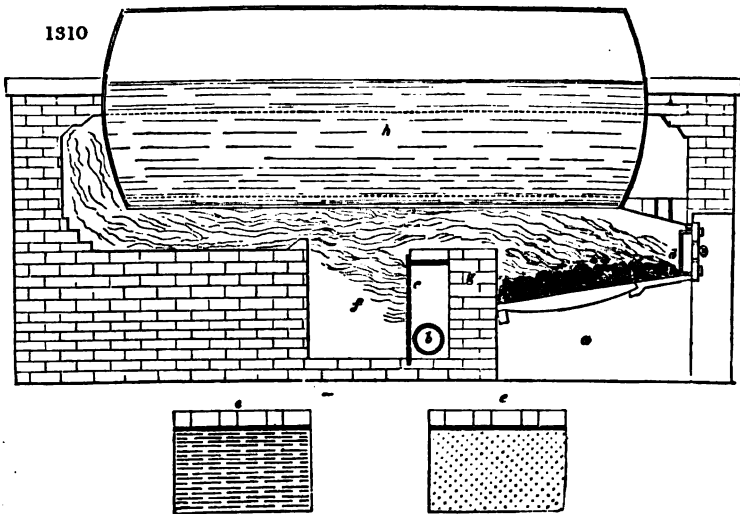


lever, *d, z*, is seen in profile or vertical section; *a*, is the fulcrum wheel, upon which the lever is in equilibrio when 9 cwt. of coals are put into the cylinder; then a weight is hung on, near the end, *x*, of the lever, as an equipoise either to 9 or 12 cwt. of mine, according to circumstances; and next a weight to balance one-third of that weight of limestone. These weights of materials being introduced into the cylinder, while the barrow rests upon a level with the line *x d*, it is then rolled forward into its place as shown in the figure, upon the wheels, *b b*, upon a platform sustained on the top of an inverted cylinder within the cast-iron column, into which cylinder air is admitted (through a valve opened by the workman) from the furnace blast, the air passing up the tube seen in the axis of *r*. The inverted air-cylinder is $3\frac{1}{2}$ feet in diameter, 36 feet long, and rises 25 feet; being made air-tight with water, it ascends in its columnar case which is 4 feet in diameter, without friction. The space, *a n*, *fig.* 1309. is 36 feet square.

The iron cone, which serves as a valve to the charging-drum or cylinder, is raised and lowered by means of a chain passing round a worm-wheel, which is turned round by an endless screw, acted upon by the long rod at *c*, which the workman can move by hand at pleasure, thereby lowering or raising the end of the short lever, *d*, to which the valve cone is suspended. The cord by which the workman opens or shuts the air piston-valve is seen at *e, f*. I have viewed with much pleasure the precise and easy movements of this feed-apparatus, at an excellent blast furnace in Codner Park iron works.

SMOKE PREVENTION. Among the fifty several inventions which have been patented for effecting this purpose, with regard to steam boilers and other large furnaces, very few are sufficiently economical or effective. The first person who investigated this subject in a truly philosophical manner was Mr. Charles Wye Williams, managing director of the Dublin and Liverpool Steam Navigation Company, and he also has had the merit of constructing many furnaces both for marine and land steam-engines, which thoroughly prevent the production of smoke, with increased energy of combustion, and a more or less considerable saving of fuel, according to the care of the stoker. The specific invention, for which he obtained a patent in 1840, consists in the introduction of a proper quantity of atmospheric air to the bridges and flame-beds of the furnaces, through a great number of small orifices, connected with a common pipe or canal, whose area can be increased or diminished according as the circumstances of complete combustion may require, by means of an external valve. The operation of air thus entering in small jets into the half-burned hydro-carburetted gases over the fires, and in the first flue, is their perfect oxygenation, the development of all the heat which that can produce, and the entire prevention of smoke. One of the many ingenious methods in which Mr. Williams has carried out the principles of what he justly calls his Argand furnace, is represented at *fig.* 134., where *a* is the ash-pit of a steam-boiler furnace; *b*, is the

1310



mouth of a tube which admits the external air into the chamber or iron box of distribution, *e*, placed immediately beyond the fire-bridge, *g*, and before the diffusion or

mixing chamber, *f*. The front of the box is perforated either with round or oblong orifices as shown in the two small figures *e*, *e* beneath *fig.* 1310; *d*, is the fire-door which may have its fire-brick lining also perforated. In some cases, the fire-door projects in front, and it, as well as the sides and arched top of the fire-place, are constructed of perforated fire tiles, enclosed in common brickwork, with an intermediate space, into which the air may be admitted in regulated quantity through a moveable valve in the door. I have seen a fire-place of this latter construction performing admirably, without smoke, with an economy of one-seventh of the coals formerly consumed in producing a like amount of steam from an ordinary furnace; *A* is the steam boiler.

Very ample evidence was presented in a late session to the Smoke Prevention Committee of the House of Commons of the successful application of Mr. Williams's patent invention to many furnaces of the largest dimensions, more especially by Mr. Henry Hoouldsworth, of Manchester, who, mounting in the first flue a pyrometrical rod, which acted on an external dial index, succeeded in observing every variation of temperature produced by varying the introduction of the air-jets into the mass of ignited gases passing out of the furnace. He thereby demonstrated, that 20 per cent. more heat could be easily obtained from the fuel, when Mr. Williams's plan was in operation, than when the fire was left to burn in the usual way, and with the production of the usual volumes of smoke. It is to be hoped that a law will be enacted in the present session of parliament for the suppression, or at least abatement, of this nuisance, which so greatly disfigures and pollutes many parts of London, as well as all our manufacturing towns, while it acts injuriously on animal and vegetable life. Much praise is due to Mr. Williams for his indefatigable and disinterested labours in this difficult enterprise, and for his forbearance under much unmerited obloquy from narrow-minded prejudice and indocile ignorance.

SOAP (*Savon*, Fr.; *Seife*, Germ.); is a chemical compound, of saponified fats or oils with potash or soda, prepared for the purposes of washing linen, &c. Fatty matters, when subjected to the action of alkaline lyes, undergo a remarkable change, being converted into three different acids, called stearic, margaric, and oleic; and it is these acids, in fact, which combine with the bases, in definite proportions, to form compounds analogous to the neutro-saline. Some chemical writers describe under the title soap every compound which may result from the union of fats with the various earths and metallic oxides—a latitude of nomenclature which common language cannot recognise, and which would perplex the manufacturer.

Soaps are distinguished into two great classes, according to their consistence, the hard and the soft; the former being produced by the action of soda upon fats, the latter by that of potash. The nature of the fats contributes also somewhat to the consistence of soaps: thus tallow, which contains much stearine and margarine, forms with potash a more consistent soap than liquid oils will do, which consist chiefly of oleine. The drying oils, such as those of linseed and poppy, produce the softest soaps.

1. *Of the manufacture of hard soap.*—The fat of this soap, in the northern countries of Europe, is usually tallow, and in the southern, coarse olive oil. Different species of grease are saponified by soda, with different degrees of facility; among oils, the olive, sweet almond, rapeseed, and castor oil; and among solid fats, tallow, bone grease, and butter, are most easily saponified. According to the practice of the United Kingdom, six or seven days are required to complete the formation of a pan of hard soap, and a day or two more for settling the impurities, if it contains rosin. From 12 to 13 cwt. of tallow are estimated to produce one ton of good soap. Some years ago, in many manufactories the tallow used to be saponified with potash lyes, and the resulting soft soap was converted, in the course of the process, into hard soap, by the introduction of muriate of soda, or weak kelp lyes, in sufficient quantity to furnish the proper quantity of soda by the reaction of the potash upon the neutral salts. But the high price of potash, and the diminished price as well improved quality of the crude sodas, have led to their general adoption in soap-works. The soda-ash used by the soap-boiler contains in general about 36 per cent. of real soda, in the state of dry carbonate, mixed with muriate of soda, and more or less undecomposed sulphate. I have met lately with soda-ash, made from sulphate of soda, in which the materials had been so ill worked, and so imperfectly decomposed, as to contain 16 per cent. of sulphate, a circumstance equally disgraceful, as it was ruinous to the soda manufacturer. The barillas from Spain and Teneriffé contain from 18 to 24 per cent. of real soda. The alkali in both states is employed in England; barilla being supposed by many to yield a finer white or curd soap, on account of its freedom from sulphur.

The crude soda of either kind being ground is to be stratified with lime in cylindrical cast-iron vats, from 6 to 7 feet wide, and from 4 to 5 feet deep; the lowest layer consisting, of course, of unslaked or shell quicklime. The vats have a false bottom, perforated with holes, and a lateral tubulure under it, closed commonly with a wooden plug, similar to the *epine* of the French soap pans, by which the lyes trickle off clear

and caustic, after infiltration through the beds of lime. The quantity of lime must be proportional to the carbonic acid in the soda.

Upon 1 ton of tallow put into the soap pan, about 200 gallons of soda lye, of specific gravity 1.040, being poured, heat is applied, and after a very gentle ebullition of about 4 hours, the fat will be found to be completely saponified, by the test of the spatula, trowel, or pallet knife; for the fluid lye will be seen to separate at once upon the steel blade, from the soapy paste. Such lyes, if composed of pure caustic soda, would contain 4 per cent. of alkali; but from the presence of neutro-saline matter, they seldom contain so much as 2 per cent.; in fact, a gallon may be estimated to contain not more than 2 ounces; so that 200 gallons contain 25 pounds of real soda. The fire being withdrawn from the soap pan, the mass is allowed to cool during one hour, or a little more, after which the spent lyes, which are not at all alkaline, are run off by a spigot below, or pumped off above, by a pump set into the pan. A second similar charge of lye is now introduced into the pan, and a similar boiling process is renewed. Three such boils may be given in the course of one day's work by an active soap-maker. Next day the same routine is resumed with somewhat stronger lyes, and so progressively, till, towards the sixth day, the lye may have the density of 1.160, and will be found to contain 6 per cent. of real soda.* Were the lye a solution of pure caustic soda, it would contain at this density no less than 14½ per cent. of alkali. The neutro-saline matter present in the spent lye is essential to the proper granulation and separation of the saponaceous compound; for otherwise the watery menstruum would dilute and even liquefy the soap. Supposing 12½ cwt. of tallow to yield upon an average 20 cwt. of hard soap, then 20 cwt. of tallow will produce 32 cwt.; and as its average contents in soda are 6 per cent., these 32 cwt. should require 1.52 cwt. of real soda for their production. If barilla at 20 per cent. be the alkali employed, then 7.6 cwt. of barilla must be consumed in the said process. If the alkali be soda-ash of 40 per cent., half the weight will of course suffice. I have reason to believe that there is great waste of alkali incurred in many soap-works, a 6 cwt. of soda-ash, of at least 30 per cent., is often expended in making 1 ton of soap, being 50 per cent. more than really enters into the composition of the soap.

The barillas always contain a small proportion of potash, to which their peculiar value, in making a less brittle or more plastic hard soap than the factitious sodas, may with great probability be ascribed. Chemistry affords many analogies, especially in mineral waters, where salts, apparently incompatible, co-exist in dilute solutions. We may thus conceive how a small quantity of stearate or oleate of potash may resist the decomposing action of the soda salts. The same modification of the consistence of hard soap may, however, be always more conveniently produced by a proper admixture of oleine with stearine.

Soda which contains sulphurets is preferred for making the mottled or marbled soap, whereas the desulphuretted soda makes the best white curd soap. Mottling is usually given in the London soap-works, by introducing into the nearly finished soap in the pan a certain quantity of the strong lye of crude soda, through the rose spout of a watering-can. The dense sulphuretted liquor, in descending through the pasty mass, causes the marbled appearance. In France a small quantity of solution of sulphate of iron is added during the boiling of the soap, or rather with the first service of the lyes. The alkali seizes the acid of the sulphate, and sets the protoxide of iron free, to mingle with the paste, to absorb more or less oxygen, and to produce thereby a variety of tints. A portion of oxide combines also with the stearine to form a metallic soap. When the oxide passes into the red state, it gives the tint called *manteau Isabelle*. As soon as the *mottler* has broken the paste, and made it pervious in all directions, he ceases to push his rake from right to left, but only plunges it perpendicularly, till he reaches the lye; then he raises it suddenly in a vertical line, making it act like the stroke of a piston in a pump, whereby he lifts some of the lye, and spreads it over the surface of the paste. In its subsequent descent through the numerous fissures and channels, on its way to the bottom of the pan, the coloured lye impregnates the soapy particles in various forms and degrees, whence a varied marbling results.

Three pounds of olive oil afford five pounds of marbled Marseilles soap of good quality, and only four pounds four ounces of white soap; showing that more water is retained by the former than the latter. Oil of grains, as linseed and rapeseed, do not afford so solid a soda soap as oil of olives; but tallow affords a still harder soap with soda. Some of the best Windsor soap made in London contains one part of olive oil (gallipoli) for every nine parts of tallow. Much of the English hard soap is made with kitchen and bone fat, of a very coarse quality; the washing of the numerous successive lyes, however, purifies the foul fats, and deprives them of their offensive smell in a great degree. It is common now at Marseilles to mix ten per cent. of the oil of grains with olive oil; for which purpose a large proportion of the oils extracted from

* According to my own experiments upon the soda lye used in the London soap-works.

seeds in the mills of the *Département du Nord* is sent to Marseilles; but five per cent. of poppy-seed oil, mixed with tallow, renders the soap made with the mixture stringy and unfit for washing; because the two species of fat refuse to amalgamate.

The affinity between the stearine of tallow and the alkali is so great that a soap may be speedily made from them in the cold. If we melt tallow at the lowest possible temperature, and let it cool to the fixing point, then add to it half its weight of caustic lye, at 36° B., agitating meanwhile incessantly with a pallet knife, we shall perceive, at the end of some hours of contact, the mixture suddenly acquire a very solid consistence, and at the same moment assume a marked elevation of temperature, proving the phenomenon to be due to chemical attraction. In some trials of this kind, the thermometer has risen from 54° to 140° F.

According to experiments made in Marseilles, 100 pounds of olive oil take, for their conversion into soap, 54 pounds of crude soda, of 36 per cent. alkaline strength. One part of lime is employed for rendering three parts of the soda caustic. The richer the oil is in stearine, the more dilute should be the lye used in the saponification; and *vice versa* when it abounds in oleine. For oil of the former kind, the first lyes added have a density of from 8° to 9° B.; but for the latter kind, the density is from 10° to 11°. When four parts of olive oil are mixed with one part of poppy, rape, or linseed oil, as is now the general practice at Marseilles, then for such a mixture the first lyes have usually a specific gravity of from 20° to 25°, the second from 10° to 15°, and the third from 4° to 5°, constituting a great difference from the practice in Great Britain, where the weaker lyes are generally employed at the commencement. The chief reason for this practice is, however, to be found in the more complete causticity of the weak than of the strong lyes, according to the slovenly way in which most of our soap-boilers prepare them. Indeed, one very extensive manufacturer of soap in London assured me that the lyes should not be caustic; an extraordinary assertion, upon which no comment need be made. In common cases, I would recommend the first combination of the ingredients to be made with somewhat weak, but perfectly caustic lye, and when the saponification is fairly established, to introduce the stronger lye.

In a Marseilles soap-house, there are four lye-vats in each set: No. 1. is the *fresh vat*, into which the fresh alkali and lime are introduced; No. 2. is called the *avancaire*, being one step in advance; No. 3. is the small *avancaire*, being two steps in advance, and therefore containing weaker liquor; No. 4. is called the *water vat* because it receives the water directly.

Into No. 3. the moderately exhausted or somewhat spent lyes are thrown. From No. 3. the lye is run or pumped into No. 2. to be strengthened; and in like manner from No. 3. into No. 1. Upon the lime paste in No. 4., which has been taken from No. 3., water is poured; the lye thus obtained is poured upon the paste of No. 3., which has been taken from No. 2. No. 3. is twice lixiviated; and No. 2. once. The receiver under No. 1. has four compartments; into No. 1. of which the first and strongest lye is run; into No. 2. the second lye; into No. 3. the third lye; and into No. 4. the fourth lye, which is so weak as to be used for lixiviation, instead of water; (*pour d'avances*).

The lime of vat No. 4., when exhausted, is emptied out of the window near to which it stands; in which case the water is poured upon the contents of No. 3.; and upon No. 2. the somewhat spent lyes.

No. 1. is now the *avancaire* of No. 4.; because this has become, in its turn, the *fresh vat*, into which the fresh soda and quicklime are put. The lye discharged from No. 3. comes, in this case, upon No. 2.; and after being run through it, is thrown upon No. 1.

144 pounds of oil yield at Marseilles, upon an average, not more than 240 to 244 pounds of soap; or 100 pounds yield about 168; so that in making 100 pounds of soap, at this rate, nearly 60 pounds of oil are consumed.

OF YELLOW OR ROSIN SOAP.

Rosin, although very soluble in alkaline menstrua, is not however susceptible, like fats, of being transformed into an acid, and will not of course saponify, or form a proper soap by itself. The more caustic the alkali, the less consistence has the resinous compound which is made with it. Hence fat of some kind, in considerable proportion, must be used along with the rosin, the *minimum* being equal parts; and then the soap is far from being good. As alkaline matter cannot be neutralized by rosin, it preserves its peculiar acrimony in a soap poor in fat, and is ready to act too powerfully upon woollen and all other animal fibres to which it is applied. It is said that rancid tallow serves to mask the strong odour of rosin in soap, more than any oil or other species of fat. From what we have just said, it is obviously needless to make the rosin used for yellow soaps pass through all the stages of the saponifying process; nor would this indeed be proper, as a portion of the rosin would be carried away, and wasted with the spent lyes. The best mode of proceeding, therefore, is first of all to make the hard soap in the usual manner, and at the last

service or charge of lye, namely, when this ceases to be absorbed, and preserves in the boiling-pan its entire causticity, to add the proportion of rosin intended for the soap. In order to facilitate the solution of the rosin in the soap, it should be reduced to coarse powder, and well incorporated by stirring with the rake. The proportion of rosin is usually from one-third to one-fourth the weight of the tallow. The boil must be kept up for some time with an excess of caustic lye; and when the paste is found, on cooling a sample of it, to acquire a solid consistence, and when diffused in a little water, not to leave a resinous varnish on the skin, we may consider the soap to be finished. We next proceed to draw off the superfluous lyes, and to purify the paste. For this purpose, a quantity of lyes at 80° B. being poured in, the mass is heated, worked well with a rake, then allowed to settle, and drained of its lyes. A second service of lyes, at 4° B., is now introduced, and finally one at 2°; after each of which, there is the usual agitation and period of repose. The pan being now skimmed, and the scum removed for another operation, the soap is laded off by hand-pails into its frame-moulds. A little palm oil is usually employed in the manufacture of yellow soap, in order to correct the flavour of the rosin, and brighten the colour. This soap, when well made, ought to be of a fine wax-yellow hue, be transparent upon the edges of the bars, dissolve readily in water, and afford, even with hard pump-water, an excellent lather.

The frame-moulds for hard soap are composed of strong wooden bars, made into the form of a parallelogram, which are piled over each other, and bound together by screwed iron rods, that pass down through them. A square well is thus formed, which in large soap factories is sometimes 10 feet deep, and capable of containing a couple of tons of soap.

Mr. Sheridan some time since obtained a patent for combining silicate of soda with hard soap, by triturating them together in the hot and pasty state with a crutch in an iron pan. In this way from 10 to 30 per cent. of the silicate may be introduced. Such soap possesses very powerful detergent qualities, but it is apt to feel hard and be somewhat gritty in use. The silicated soda is prepared by boiling ground flints in a strong caustic lye, till the specific gravity of the compound rises to nearly double the density of water. It then contains about 35 grains of silica, and 46 of soda-hydrate, in 100 grains.*

Hard soap, after remaining two days in the frames, is at first divided horizontally into parallel tablets, 3 or 4 inches thick, by a brass wire; and these tablets are again cut vertically into oblong nearly square bars, called wedges in Scotland.

The soap-pans used in the United Kingdom are made of cast iron, and in three separate pieces joined together by iron-rust cement. The following is their general form:— The two upper frustra of cones are called curbs; the third, or undermost, is the pan, to which alone the heat is applied, and which, if it gets cracked in the course of boiling, may easily be lifted up within the conical pieces, by attaching chains or cords for raising it, without disturbing the masonry, in which the curbs are firmly set. The surface of the hemispherical pan at the bottom, is in general about one-tenth part of the surface of the conical sides.

The white ordinary tallow soap of the London manufacturers, called curd soap, consists, by my experiments, of— fat, 52; soda, 6; water, 42; = 100. Nine-tenths of the fat, at least, is tallow.

I have examined several other soaps, and have found their composition somewhat different.

The foreign Castile soap of the apothecary has a specific gravity of 1.0705, and consists of—

| | |
|------------------------------------|-------|
| Soda - - - - | 9 |
| Oily fat - - - - | 76.5 |
| Water and colouring matter - - - - | 14.5 |
| | 100.0 |

English imitation of Castile soap, spec. grav. 0.9669, consists of—

| | |
|---|-------|
| Soda - - - - | 10.5 |
| Fatty-consistenced fat - - - - | 75.2 |
| Water, with a little colouring-matter - - - - | 14.3 |
| | 100.0 |

A perfumer's white soap was found to consist of—

| | |
|----------------------|-----|
| Soda - - - - | 9 |
| Fatty matter - - - - | 75 |
| Water - - - - | 16 |
| | 100 |

Glasgow white soap —

| | |
|----------------|-------|
| Soda - - - - | 6.4 |
| Tallow - - - - | 60.0 |
| Water - - - - | 33.6 |
| | 100.0 |

* By my own experiments upon the liquid silicate made at Mr. Gibbs's excellent soap factory.

| | | | |
|---------------------------|---|---|-------|
| Glasgow brown rosin soap— | | | |
| Soda - | - | - | 6·5 |
| Fat and rosin - | - | - | 70·0 |
| Water - | - | - | 23·5 |
| | | | <hr/> |
| | | | 100·0 |

A London cocoa-nut oil soap was found to consist of—

| | | | |
|------------------|---|---|-------|
| Soda - | - | - | 4·5 |
| Cocoa-nut lard - | - | - | 23·0 |
| Water - | - | - | 73·5 |
| | | | <hr/> |
| | | | 100·0 |

This remarkable soap was sufficiently solid; but it dissolved in hot water with extreme facility. It is called marine soap, because it washes linen with sea water.

| | | | |
|---|---|---|-------|
| A poppy-nut-oil hard soap consisted of— | | | |
| Soda - | - | - | 7 |
| Oil - | - | - | 76 |
| Water - | - | - | 17 |
| | | | <hr/> |
| | | | 100* |

The soap known in France by the name of soap in *tables* consists, according to M. Thenard's analysis, of—

| | | | |
|----------------|---|---|-------|
| Soda - | - | - | 4·6 |
| Fatty matter - | - | - | 50·2 |
| Water - | - | - | 45·2 |
| | | | <hr/> |
| | | | 100 |

M. D'Arcet states the analysis of Marseilles soap at—

| | | | |
|---------|---|---|-------|
| Soda - | - | - | 6 |
| Oil - | - | - | 60 |
| Water - | - | - | 34 |
| | | | <hr/> |
| | | | 100 |

SOFT SOAP.

The principal difference between soaps with base of soda, and soaps with base of potash, depends upon their mode of combination with water. The former absorb a large quantity of it, and become solid; they are chemical hydrates. The others experience a much feebler cohesive attraction; but they retain much more water in a state of mere mixture.

Three parts of fat afford, in general, fully five parts of soda soap, well dried in the open air; but three parts of fat or oil will afford from six to seven parts of potash soap of moderate consistence. This feebler cohesive force renders it apt to deliquesce, especially if there be a small excess of the alkali. It is, therefore, impossible to separate it from the lye; and the washing or *relargage*, practised on the hard-soap process, is inadmissible in the soft. Perhaps, however, this concentration or abstraction of water might be effected by using dense lyes of muriate of potash. Those of muriate or sulphate of soda change the potash into a soda soap, by double decomposition. From its superior solubility, more alkaline reaction, and lower price, potash soap is preferred for many purposes, and especially for scouring woollen yarns and stuffs.

Soft soaps are usually made in this country with whale, seal, olive, and linseed oils, and a certain quantity of tallow; on the continent, with the oils of hempseed, sesame, rapeseed, linseed, poppy-seed, and colza; or with mixtures of several of these oils. When tallow is added, as in Great Britain, the object is to produce white and somewhat solid grains of stearic soap in the transparent mass, called *figging*, because the soap then resembles the granular texture of the fig.

The potash lyes should be made perfectly caustic, and of at least two different strengths, the weakest being of specific gravity 1·05; and the strongest, 1·20, or even 1·25. Being made from the potashes of commerce, which contains seldom more than 60 per cent, and often less, of real alkali, the lyes correspond in specific gravity to double their alkaline strength; that is to say, a solution of pure potash, of the same density, would be fully twice as strong. The following is the process followed by respectable manufacturers of soft soap (*savon vert*, being naturally or artificially green,) upon the continent.

A portion of the oil being poured into the pan, and heated to nearly the boiling point of water, a certain quantity of the weaker lye is introduced; the fire being kept up so as to bring the mixture to a boiling state. Then some more oil and lye are added alternately, till the whole quantity of oil destined for the pan is introduced. The ebullition is kept up in the gentlest manner possible, and some stronger lye is occasionally added, till the workman judges the saponification to be perfect. The boiling becomes progressively less tumultuous, the frothy mass subsides, the paste grows transparent, and it gradually thickens. The operation is considered to be finished when the paste ceases to affect the tongue with an acrid pungency, when all milkiness and opacity disappear, and when a little of the soap placed to cool upon a glass-plate, assumes the proper consistency.

A peculiar phenomenon may be remarked in the cooling, which affords a good criterion of the quality of the soap. When there is formed around the little patch, an opaque zone, a fraction of an inch broad, this is supposed to indicate complete saponification, and is called the *strength*; when it is absent, the soap is said to want its *strength*. When this zone soon vanishes after being distinctly seen, the soap is said to have *false strength*. When it occurs in the best form, the soap is perfect, and may be secured in

* My own experiments. See Fats, Oils, and Stearine.

that state by removing the fire, and then adding some good soap of a previous round to cool it down, and prevent further change by evaporation.

200 pounds of oil require for their saponification—72 pounds of American potash of moderate quality, in lyes at 15° B.; and the product is 460 pounds of well-boiled soap.

If hempseed oil have not been employed, the soap will have a yellow colour, instead of the green, so much in request on the Continent. This tint is then given by the addition of a little indigo. This dye-stuff is reduced to fine powder, and boiled for some hours in a considerable quantity of water, till the stick with which the water is stirred presents, on withdrawing it, a gilded pellicle over its whole surface. The indigo paste diffused through the liquid, is now ready to be incorporated with the soap in the pan, before it stiffens by cooling.

M. Thenard states the composition of soft soap at—potash 9.5, + oil 44.0 + water 46.5, = 100.

Good soft soap of London manufacture yielded to me—potash 8.5, + oil and tallow 45, + water 46.5.

Belgian soft or green soap afforded me—potash 7, + oil 36, + water 57, = 100.

Scotch soft soap, being analyzed, gave me—potash 8, + oil and tallow 47, + water 45.

Another well-made soap—potash 9, + oil and fat 34, + water 57.

A rapeseed-oil soft soap, from Scotland, consisted of—potash 10, + oil 51.66, + water 38.33.

An olive-oil (gallipoli) soft soap, from ditto, contained—potash with a good deal of carbonic acid 10, oil 48, water 42, = 100.

A semi-hard soap, from Verviers, for fulling woollen cloth, called *savon economique*, consisted of, potash 11.5, + fat (solid) 62, + water 26.5, = 100.

The following is a common process, in Scotland, by which good soft soap is made:—

273 gallons of whale or cod oil, and 4 cwt. of tallow, are put into the soap-pan, with 250 gallons of lye from American potash, of such alkaline strength that 1 gallon contains 6600 grains of real potash. Heat being applied to the bottom pan, the mixture froths up very much as it approaches the boiling temperature, but is prevented from boiling over by being beat down on the surface, within the iron curb or crib which surmounts the cauldron. Should it soon subside into a doughy-looking paste, we may infer that the lye has been too strong. Its proper appearance is that of a thin glue. We should now introduce about 42 gallons of a stronger lye, equivalent to 8700 gr. of potash per gallon; and after a short interval, an additional 42 gallons; and thus successively till nearly 600 such gallons have been added in the whole. After suitable boiling to saponify the fats, the proper quality of soap will be obtained, amounting in quantity to 100 firkins of 64 pounds each, from the above quantity of materials.

It is generally supposed, and I believe it to be true, from my own numerous experiments upon the subject, that it is a more difficult and delicate operation to make a fine soft soap of glassy transparency, interspersed with the figged granulations of stearate of potash, than to make hard soap of any kind.

Soft soap is made in Belgium as follows:—For a boil of 18 or 20 tons, of 100 kilogrammes each, there is employed for the lyes—1500 pounds of American potashes, and 500 to 600 pounds of quicklime.

The lye is prepared cold in cisterns of hewn stone, of which there are usually five in a range. The first contains the materials nearly exhausted of their alkali; and the last the potash in its entire state. The lye run off from the first is transferred into the second; that of the second into the third; and so on to the fifth.

In conducting the *empatage* of the soap, they put into the pan, on the eve of the boiling-day, six *aines* (one ohm, = 30 gallons imperial,) of oil of colza, in summer, but a mixture of that oil with linseed oil in winter, along with two aimes of potash lye at 13° B., and leave the mixture without heat during eight hours. After applying the fire, they continue to boil gently till the materials cease to swell up with the heat; after which, lye of 16° or 17° must be introduced successively, in quantities of one quarter of an aime after another, till from 2 to 4 aimes be used. The boil is finished by pouring some lye of 20° B., so that the whole quantity may amount to 9½ aimes.

It is considered that the operation will be successful, if from the time of kindling the fire till the finish of the boil, only five hours elapse. In order to prevent the soap from boiling over, a wheel is kept revolving in the pan. The operative considers the soap to be finished, when it can no longer be drawn out into threads between the finger and thumb. He determines if it contains an excess of alkali, by taking a sample out during the boil, which he puts into a tin dish; where if it gets covered with a skin, he pours fresh oil into the pan, and continues the boil till the soap be perfect. No wonder the Belgian soap is bad, amid such groping in the dark, without one ray of science!

SOFT TOILET SOAPS.

The soft fancy toilet soaps are divisible into two classes: 1. good *potash soap*, coloured and scented in various ways, forms the basis of the Naples and other ordinary soft soaps

of the perfumer; 2. *pearl soap* (*sapon nacre*), which differs from the other both in physical aspect and in mode of preparation.

Ordinary soft Toilet Soap.—Its manufacture being conducted on the principles already laid down, presents no difficulty to a man of ordinary skill and experience; the only point to be strictly attended to, is the degree of evaporation, so as to obtain soap always of uniform consistence. The fat generally preferred is good hog's lard; of which 30 pounds are to be mixed with 45 pounds of a caustic lye marking 17° on Baumé's scale; the temperature is to be gradually raised to ebullition, but the boil must not be kept up too long or too briskly, till after the *empâtage* or saponification is completed, and the whole of the lye intimately combined with the fatty particles; after this, the evaporation of the water may be pushed pretty quickly, by a steady boil, till copious vapours cease to rise. This criterion is observed when the paste has become too stiff to be stirred freely. The soap should have a dazzling snowy whiteness, provided the lard has been well refined, by being previously triturated in a mortar, melted by a steam heat, and then strained. The lard soap so prepared is semi-solid, and preserves always the same appearance. If the paste is not sufficiently boiled, however, it will show the circumstance very soon; for in a few days the soap will become gluey and stringy, like a tenacious mass of birdlime. This defect may not only be easily avoided, but easily remedied, by subjecting the paste to an adequate evaporation. Such soaps are in great request for shaving, and are most convenient in use, especially for travellers. Hence their sale has become very considerable.

Pearl soft Soap.—It is only a few years since the process for making this elegant soap became known in France. It differs little from the preceding, and owes its beautiful aspect merely to minute manipulations, about to be described. Weigh out 30 pounds of purified hog's lard on the one hand; and 10 pounds of potash lye at 36° B. on the other. Put the lard into a porcelain capsule, gently heated upon a sand-bath, stirring it constantly with a wooden spatula; and when it is half melted, and has a milky appearance, pour into it only one-half of the lye, still stirring, and keeping up the same temperature, with as little variation as possible. While the saponification advances gradually, we shall perceive, after an hour, some fat floating on the surface, like a film of oil, and at the same time the soapy granulations falling to the bottom. We must then add the second portion of the lye; whereon the granulations immediately disappear and the paste is formed. After conducting this operation during four hours, the paste becomes so stiff and compact, that it cannot be stirred; and must then be lightly beaten. At this time the capsule must be transferred from the sand-bath into a basin of warm water, and allowed to cool very slowly.

The soap, though completely made, has yet no pearly appearance. This physical property is developed only by pounding it strongly in a marble mortar; whereby all its particles, which seemed previously separated, combine to form a homogeneous paste. The perfume given to it is always essence of bitter almonds; on which account the soap is called *almond cream*, *crème d'amandes*.

HARD SOAPS FOR THE TOILET.

The soaps prepared for the perfumer, are distinguished into different species, according to the fat which forms their basis. Thus there is soap of tallow, of hog's lard, of oil of olives, of almonds, and palm oil.

It is from the combination of these different sorts, mingled in various proportions, and perfumed agreeably to the taste of the consumer, that we owe the vast number of toilet soaps sold under so many fantastic names. One sort is rarely scented by itself, as a mixture of several is generally preferred; in which respect every perfumer has his peculiar secret. Some toilet soaps, however, require the employment of one kind more than of another.

Formerly the Windsor soap was made in France, wholly with mutton suet; and it was accordingly of inferior value. Now, by mixing some olive oil or lard with the suet, a very good Windsor soap is produced. I have already stated, that the fat of the London Windsor is, nine parts of good ox tallow, and one of olive oil. A soap made entirely with oil and soda does not afford so good a lather as when it contains a considerable proportion of tallow.

The soaps made with palm oil are much used; when well made, they are of excellent quality, and ought to enter largely into all the coloured sorts. They naturally possess the odour of violets.

The soap made with oil of almonds are very beautiful, and preserve the agreeable smell of their perfume; but being expensive, are introduced sparingly into the mixtures by most manufacturers.

Some perfumers are in the habit of making what may be called extempore soaps, employing lyes at 36° Baumé in their formation. This method, however, ought never to be adopted by any person who prefers quality to beauty of appearance. Such soap is, indeed, admirably white, glistening, contains no more water than is necessary to its con-

stitution, and may therefore be sold the day after it is made. But it has counterbalancing disadvantages. It becomes soon very hard, is difficultly soluble in water, and, if not made with tallow, does not lather well. Hog's lard is very commonly used for making that soap. Twenty kilogrammes of the fat are taken to ten kilogrammes of soda lye, at 36° B. (specific gravity 1.324); as soon as the former is nearly fluid, 5 kilogrammes of the lye are introduced, and the mixture is continually agitated during an hour with a wooden spatula. The temperature should never be raised above 150° Fahr. at the commencement of the operation; at the end of one hour, 5 other kilogrammes of lye are to be added, with careful regulation of the heat. The paste thus formed by the union of the fat and alkali ought to be perfectly homogeneous, and should increase in consistence every hour, till it becomes firm enough to be poured into the frame; during which transfer, the essential oils destined to scent it, should be introduced. Next day the soap is hard enough; nor does it differ in appearance from ordinary soap, only it requires prompt manipulation to be cut into bars and cakes; for when neglected a day or two, it may become too brittle for that purpose, and too hard to take the impression of the stamps in relief. Such an article gets the name of *little-pan soap*, on account of the small quantity in which it is usually manufactured. Hard soap, made in the common way, is, on the contrary, called *large-pan soap*. This extemporaneous compound is now seldom or never made by respectable manufacturers. In making Windsor soap, the admixture of olive oil is advantageous; because, being richer in oleine than suet, it saponifies less readily than it, and thus favours the formation of a more perfect neutral combination. When the soap cuts, or parts from the lye, when the paste becomes clotty, or, in the language of the operative, when the grain makes its appearance, the fire should be immediately withdrawn, that the impurities may be allowed to subside. This part of the operation lasts 12 hours at least; after which, the soap, still hot, becomes altogether fluid and perfectly neutral.

For every 1000 pounds of the paste, there must be introduced 9 pounds of essences, mingled in the following proportions: —6 pounds of essence of carui; 1½ ditto lavender (finest); 1½ ditto rosemary.

The mixture must be well stirred, in order to get completely saturated with the perfumes; and this may be readily done without at all touching or stirring up the subjacent lyes; in the course of two hours, the soap may be transferred into the ordinary frames. In twenty-four hours, the mass is usually solidified enough for cutting into bars and cakes, ready to be stamped for sale.

The above method of scenting Windsor soap is practised only in the largest establishments; in the smaller, the soap is pailed out of the soap-pan, into a pan provided with a steam case or jacket, and there mixed with the essential oils, by means of appropriate heat and agitation.

The most fashionable toilet soaps are, the rose, the *bouquet*, the cinnamon, the orange-flower, the musk, and the bitter almond or peach blossom.

Soap à la rose. — This is made of the following ingredients: 30 pounds of olive-oil soap; 20 of good tallow soap.

Toilet soaps must be reduced to thin shavings, by means of a plane, with its under face turned up, so that the bars may be slid along it. These shavings must be put into an untinned copper pan, which is surrounded by a water-bath or steam. If the soap be old and hard, 5 pounds of water must be added to them; but it is preferable to take fresh-made soaps, which may melt without addition, as soap some time kept does not readily form a homogeneous paste. The fusion is commonly completed in an hour, or thereby, the heat being applied at 212° F., to accelerate the progress, and prevent the dissolution of the constituent water of the soap. For this purpose the interior pan may be covered. Whenever the mass is sufficiently liquefied, 1½ ounces of finely ground vermilion are to be introduced, and thoroughly mixed, after which the heat may be taken off the pan; when the following perfumes may be added with due trituration: — 3 ounces of essence of rose; 1 ditto cloves; 1 ditto cinnamon; 2½ ditto bergamot; = 7½.

The scented soap being put into the frames speedily consolidates. Some recommend to pass the finished fused soap through a tammy cloth, in order to free it from all clots and impurities, a very proper precaution in the act of transferring it to the frame. If the preceding instructions be observed, we obtain a soap perfect in every point of view; possessing a delicious fragrance, equally rich and agreeable, a beautiful roseate hue, and the softest detergent qualities, which keeping cannot impair. Such a soap has, in fact, been known to retain every property in perfection during four or five years. When the essential oils are particularly volatile, they should not be added to the soap till its temperature has fallen to about 140° Fahr.; but in this case a more careful trituration is required. The economy is, however, ill bestowed; for the cakes made of such cooler soap, are never so homogeneous and glossy.

Soap au bouquet. — 30 pounds of good tallow soap; 4 ounces of essence of bergamot; oil of cloves, saffras, and thyme, 1 ounce each; neroli, ½ ounce. The colour is given with 7 ounces of brown ochre.

Cinnamon Soap.—30 pounds of good tallow soap; 20 ditto of palm-oil soap. Perfumes:—7 ounces of essence of cinnamon; 1½ ditto sassafras; 1½ ditto bergamot. Colour:—1 pound of yellow ochre.

Orange-flower Soap.—30 pounds of good tallow soap; 20 ditto palm-oil soap. Perfumes:—7½ ounces essence of Portugal; 7½ ditto amber. Colour:—9½ ounces, consisting of 8½ of a yellow-green pigment, and 1½ of red lead.

Musk Soap.—30 pounds of good tallow soap; 20 ditto palm-oil soap. Perfumes:—Powder of cloves, of pale roses, gilliflower, each 4½ ounces; essence of bergamot, and essence of musk, each 3½ ounces. Colour:—4 ounces of brown ochre, or Spanish brown.

Bitter Almond Soap.—Is made by compounding, with 50 pounds of the best white soap, 10 ounces of the essence of bitter almonds.

LIGHT SOAPS.

The apparatus employed for making these soaps, is a copper pan, heated by a water-bath; in the bottom of the pan there is a step, to receive the lower end of a vertical shaft, to which arms or paddles are attached, for producing constant agitation, by causing them to revolve among the liquefied mass. Into a pan so mounted, 50 pounds of a good oil soap of any kind are put (for a tallow soap does not become frothy enough), and melted by a proper heat, with the addition of 3 or 4 pounds of water. By the rapid rotation of the machine, an abundant thick lather is produced, beginning first at the bottom, and creeping gradually upwards to the top of the pan, when the operation should be stopped; the soap having by this time doubled its volume. It must now be pailed off into the frame, allowed to cool, and then cut into cakes. Such soap is exceedingly pleasant at the wash-stand, feeling very soft upon the skin, affording a copious thick lather, and dissolving with the greatest ease.

TRANSPARENT SOAPS.

These soaps were for a long time manufactured only in England, where the process was kept a profound secret. They are now made every where.

Equal parts of tallow soap, made perfectly dry, and spirit of wine, are to be put into a copper still, which is plunged in a water-bath, and furnished with its capital and refrigeratory. The heat applied to effect the solution should be as slight as possible, to avoid evaporating too much of the alcohol. The solution being effected, must be suffered to settle; and after a few hours' repose, the clear supernatant liquid is drawn off into tin frames, of the form desired for the cakes of soap. These bars do not acquire their proper degree of transparency till after a few weeks' exposure to dry air. They are now planed, and subjected to the proper mechanical treatment for making cakes of any form. The soap is coloured with strong alcoholic solution of archil for the rose tint, and of turmeric for the deep yellow. Transparent soaps, however pleasing to the eye, are always of indifferent quality; they are never so detergent as ordinary soaps, and they eventually acquire a disagreeable smell.

The exports of soap from this country during the last 9 months, (November 1852), were 117,623 cwt. against 99,983 cwt. in 1851, and 96,123 in 1850.

The following is an invention for which Dr. Normandy obtained a patent. When yellow soap is made with the cheaper kinds of fat, it will hardly acquire a sufficient degree of firmness or hardness to satisfy the thrifty washerwoman. It melts away too rapidly in hot water; a defect which may be well remedied by the introduction into the soap of a little fused sulphate of soda; and the salt concreting gives the soap a desirable hardness, while it improves its colour, and renders it a more economical article for the washing-tub. In a trial recently before the Court of Common Pleas, it was proved that the soap made according to Dr. Normandy's patent was worth fully 2*l.* a ton more than the original soap, without the sulphate of soda.

Soda-ash is the substance employed in the manufacture of soap, and varies in the amount of soda it contains to the extent of from 30 to 50 per cent., according to the mode of its formation. A small quantity of this soda is occasionally in the caustic state; but the great bulk is combined with carbonic acid, as carbonate of soda, and variable proportions of chloride of sodium and sulphate of soda exist with it in the soda-ash. The fabrication of soap is under the surveillance of the excise, and consequently there is little or no scope for improvement,—an assertion well supported by the notorious fact, that no alteration has taken place in it since the reign of Queen Anne. Yet, looking upon the innumerable changes and metamorphoses which the fats and oils are capable of undergoing through the agency of chemistry, there is no subject which offers a fairer field for the labours of inventive genius than this very manufacture. The elements united together in the class of animal and vegetable oils or fats are not numerous, but seemingly fitted for displaying an endless mutability; and no doubt the day will come, when, from perhaps the cheapest and most worthless of these substances, we shall be able to form every other variety; or, even from wood and coal extract substances of this kind to rival and supersede tallow, wax, or spermaceti. At present, however, the

principal manufacturer interested in the working out of such questions lies under the inquisitorial power of our great fiscal harpy. Improvement under such an influence loses its reward; for concealment is impossible, not only for the period required to seal a patent, but even for a day or an hour. The excise officer is omnipotent in a soap work, for he carries the master key of every lock on the premises: all must open when he knocks: all must explain when he questions. In spite, therefore, of the thousands of interesting discoveries which have been made within the last twenty years in departments of the arts closely allied to soap-making, this manufacture has stood still for more than 200 years, and presents the most remarkable proofs of the unwholesome and impolitic nature of excise interference. Under such circumstances, we feel almost compelled to depart from our ordinary course of offering a few remarks in the direction of improvements. Hints of this kind are to the soap-maker like the water bubbling in the cup of Tantalus. He may see, but cannot enjoy, the proffered boon, for he is tied down by regulations, presumed to have been necessary for the social status of this kingdom at the time of Queen Anne. Our remarks upon the soap manufacture will consequently bear no proportion whatever to the importance of the subject or to the position which it would assume to-morrow, if relieved from excise restrictions: the incubus which has so long restrained the wing of invention would laugh at our efforts to raise the victim of his oppression.

In this department of industry, improvement has therefore, of necessity, a foreign origin, and hence we regard it as a mere matter of course that the Exhibition prize medal for soap should have passed into the hands of an American. Mr. John Ransom St. John, of New York, for the soap made under whose process a prize medal has been most justly awarded, has, we see, secured his process in this country by letters patent: yet it will not surprise us in the least to find that Mr. St. John is prevented by the excise from following out his invention here. A circumstance exactly parallel to this assumption occurred a few years ago to another foreigner, Dr. Normandy, who had taken out a patent for improvements in soap-making, but was ruinously interfered with, and ultimately stopped by the excise. In wishing Mr. St. John, therefore, all the success his extremely ingenious invention merits, we warn him that he may yet fall beneath the crushing influence of the Broad Street authorities.

The first step in the production of soap consists in obtaining a solution of soda, or what is termed caustic lye. For this purpose a given quantity of the soda-ash previously spoken of is mixed with an amount of recently slaked lime proportioned to the previously ascertained strength of the soda-ash; with these a certain bulk of sand is generally mixed, for the purpose of facilitating the subsequent process of filtration. The entire mixture is now placed, layer by layer, in a tank, similar to that described for lixiviating the ball-soda in soda works. The layers of mixture are separated by layers of rush-matting from each other, and a plug being driven into the lower orifice of the tank this latter is filled full of water and allowed to stand for twelve or eighteen hours. The plug being then withdrawn, the saturated solution of caustic soda flows down into a reservoir placed beneath; after which, the plug is again replaced, more water applied, and this operation is repeated five or six times; the various liquors thus obtained being conveyed into separate reservoirs, and distinguished from each other by the names first running, second running, and so on, the last being of course the weakest. When weak soda-ash is employed, little or no common salt need be added to the mixture in the lime vat; but when soda-ash of great strength is used, it is necessary to add a considerable quantity of common salt to it, for a purpose which will shortly be explained. Having in this way produced a series of caustic lyes, of different degrees of strength, the weakest is pumped up into a boiler copper, as it is called, though generally made of cast-iron. To this lye a quantity of tallow is added, and the whole boiled for some time, or until, upon testing it, the lye is found to have lost its caustic property. The whole is now allowed to cool and remain at rest, until the lye, now deprived of its alkali, settles to the bottom of the copper; whence it is pumped out by a kind of force-pump, as the excise regulations do not permit it to be withdrawn or run off, as it is in other countries, from the bottom of the boiler. This fluid is denominated spent lye, and contains a portion of glycerine derived from the fat or tallow, together with the sulphate and muriate of soda of the soda-ash, and an additional quantity of muriate of soda added by the soap-maker. The presence of this muriate of soda is indispensable, for otherwise the tallow and lye would unite into a uniform emulsion, from which it would be impossible afterwards to separate the spent lye; but as soap is altogether insoluble in a solution of common salt, the partially saponified compound is thus brought to float on the surface, and permits of the spent lye precipitating to the bottom, from whence, as we have seen, it is pumped away and lost, being of no value.

This constitutes what is called an operation, and, after continuing to repeat these operations three or four times, with lyes of gradually increasing strength, a period arrives at which the grease is said to be "killed," or, in other words, the tallow is

saponified, or combined with its full equivalent of soda. This point is well known to the workmen by the consistence of the compound, when a little of it is squeezed between the finger and thumb and allowed to cool; if finished, it readily separates from the skin as a hard cake, and, moreover, has no longer the taste peculiar to grease; if, on the contrary, any tallow remain unsaponified, this oozes out by the pressure, and becomes perceptible both to the sight and taste. A more certain mode, however, is to decompose a portion of the suspected soap by means of an acid, and ascertain whether the resulting grease is wholly soluble in boiling spirits of wine, for, if not, the saponification has been imperfect. Presuming, however, that a perfect result has been secured, the soap has now to be brought into a marketable condition, and, for this purpose, it is fused with a quantity of weak lye or water. So soon as combination has taken place, a quantity of very strong lye is added, until an incipient separation begins to show itself. The heat is now increased, and the boiling continued for a considerable time, the mass being prevented from boiling out of the vessel by workmen, armed with shovels, who dash the soap to and fro, so as to break the froth upon the surface, and favour evaporation. At first the soap is divided into an innumerable number of small globules, each separate and distinct from its fellow; but, as the boiling goes on, those gradually run together into larger and larger globules, till at last the soap is seen to assume a pasty consistence, and to unite in one uniform mass, through which the steam from below slowly forces its way in a series of bursts or little explosions. The process is now finished, and all that remains to be done is to shut down the lid of the copper, having previously extinguished the fire. In from one to two or three days, according to the nature and quantity of the soap in question, the lid is again raised, and the semifused soap ladled from the precipitated lye by means of ladles; the product being thrown into a wooden or iron frame, of specific dimensions, where its weight is estimated by measurement, and the duty charged upon it. In making common yellow or resin soap, the resin is usually added after the saponification of the tallow, in the proportion of one-third or one-fourth of the tallow employed. The subsequent operations are much about the same as those above described; but, in addition, just before closing the lid of the copper, a quantity of water or weak lye is sprinkled over the melted soap, which carries down with it the mechanical impurities of the resin; and these constitute a dark layer of soap resting upon the lye, which is not poured into the frame with the rest, but is placed apart under the name "*siger*," and brings a less price. Good curd or white soap should contain of

| | | | | | | | |
|--------|---|---|---|---|---|---|------------|
| Grease | - | - | - | - | - | - | 61.0 parts |
| Soda | - | - | - | - | - | - | 6.2 " |
| Water | - | - | - | - | - | - | 32.8 " |

100

or consist of

| | | | | | | | |
|-------------|---|---|---|---|---|---|----------------|
| Grease acid | - | - | - | - | - | - | 1 atom = 315 |
| Soda | - | - | - | - | - | - | 1 atom = 32 |
| Water | - | - | - | - | - | - | 17 atoms = 153 |

Resin soap has a more variable composition, but, when not adulterated with water, should contain about as follows:—

| | | | | | | | |
|------------------|---|---|---|---|---|---|----|
| Grease and resin | - | - | - | - | - | - | 60 |
| Soda | - | - | - | - | - | - | 6 |
| Water | - | - | - | - | - | - | 34 |

100

The manufacture of soft soap differs greatly from that of hard soap; as, in this case, nothing is separated from the mixture in the boiler; and the alkali employed is potash, and not soda. The mode of obtaining a caustic lye of potash is exactly the same as with soda, except that the weak lyes are used in place of water for a subsequent operation, and not pumped up into the boiler. The materials employed as fats are mixtures of the vegetable and animal oils, as rape, and the fish-oil called "*Southern*." For the best kinds of soft soap, a little tallow is added to these, which produces a peculiar kind of mottling or crystallization in the soap, that confers additional value upon it. These oils or fats are merely boiled with the strong caustic potash-lye, until thorough combination has taken place, and so much of the water of the lye is evaporated, that, when a portion of the soap is poured upon a cold slab, and allowed to rest for a few minutes, it assumes the consistence of soft butter. As soon as this happens, the whole is run out into little casks, where it cools; and is thus sent into the market. Of course no atomic arrangement can be traced in so variable a compound; and hence its

analysis presents no point of interest, The employment of soft soap is daily becoming more and more limited. Soft soap usually contains as under

| | | | | | | |
|------------|---|---|---|---|---|-----|
| Fatty oils | - | - | - | - | - | 43 |
| Potash | - | - | - | - | - | 10 |
| Water | - | - | - | - | - | 47 |
| | | | | | | 100 |

but its composition differs greatly.

Messrs. Wilson and Gwynne propose in a patent granted in 1845 to make soap from fatty matters hardened beforehand by means of sulphuric acid. 10 tons of palm oil or whale oil are put into a wrought-iron vessel provided with a perforated steam worm, through which steam is admitted till the temperature rises to 350° F.: the fatty matter is then run into a tank formed of brick lined with lead and sunk in the ground. The tank has a steam pipe inserted into it, and has a wooden cover lined with lead, having two manholes in it. It is closed by an oil joint about 8 inches deep. Through the cover a pipe passes, connected with a high shaft for the escape of offensive vapours, and their condensation by a jet of cold water. 2000 lbs. of sulphuric acid of 1·8 specific gravity are poured into the tank; the temperature of the mass being meanwhile carefully watched by a thermometer and not allowed to exceed 350° Fahr. The admission of steam is continued while the acid is being slowly poured in. When this is done the fire is extinguished. But steam is admitted for 4 hours afterwards, being heated highly by passing through pipes placed over a fire. The steam being stopped, and the mass somewhat cooled, a large pump is introduced, and the product is turned out into a wooden vessel lined with lead and provided with a steam worm. In this vessel the fatty matter is washed by means of free steam with half its bulk of water for 2 hours, and is then allowed to rest for 12 hours. The product thus obtained can be made into soap in the ordinary way; but it is better to distil it first. See *Fat*.

Soap Manufacture obstructed by our Excise Laws.—In 1831, the candle making trade was, after a long reign of oppression, emancipated from the odious excise harpies; and, says the patriotic Mr. G. F. Wilson, “those only know their cramping influence who have worked under them. Our neighbour trade, soap making, shows its injury by the fact that the German soap makers are so far in advance of ours, that they buy from us hundreds of tons of oleic acid, on which they pay freight, commissions, and other charges, while English soap makers cannot use it, though at their own doors. In France a soap work for oleic acid forms a part of almost every stearic candle factory. Here the nuisance of being subject to fixed times and rules of work, and to prying excisemen, in most cases prevents the business.”—*On the Stearic Candle Manufacture, by G. F. Wilson, Esq., Managing Director of Price's Candle Company. 1852.*

SOAPS, QUALITY OF. To determine the quantity of water, thin slices are cut from the edges and from the centre of the bars. A portion is then weighed, about 4 or 5 grammes, (60 to 70 grains), and exposed to a current of air heated to 212° Fahr., or in an oil bath, until it ceases to lose weight. The dry substance is then weighed; the difference between the first and last weighing will indicate the quantity of water evaporated. If it be a soft soap, it is weighed in a counterpoised shallow capsule. In good soap the amount of water varies from 30 to 45 per cent., in mottled and soft soaps from 36 to 52 per cent.

The purity of soap may be ascertained by treating it with hot alcohol; if the soap be white and without admixture, the portion remaining undissolved is very minute, and a mottled soap of good quality does not leave, when operating on 5 grammes, more than 5 centigrammes, or about 1 per cent.

If there should be a sensible amount of residue from white soap, or more than 1 per cent. from mottled soap, some accidental or fraudulent admixture may be suspected, — silica, alumina, gelatine, &c., the quantity and nature of which may be determined by analysis.

The quantity of alkali contained in the soap is easily determined by means of the alkalimeter.

10 grammes in thin slices are taken, for instance, and dissolved in 150 grammes of boiling water; and this solution is saturated with a normal liquor, containing in a quart of water 100 grammes of sulphuric acid, specific gravity 1·848, or with 1 atom of water.

The volume of this liquor required for complete saturation will indicate the corresponding weight of sulphuric acid, which is itself nearly equivalent to an equal weight of dry carbonate of soda.

The quantity of pure potash or soda may be thus deduced.

There is no difficulty in ascertaining in the same assay the quantity of the fatty substance. For this purpose 10 grammes of pure white wax free from water are added to the liquid, after saturation with sulphuric acid, and the whole heated to complete liquefaction: it is then allowed to cool, and when it has become solid, the cake of wax and

fatty matter which have united is removed, and washed, dried and weighed; the augmentation in weight beyond the 10 grammes employed will give the weight of the fatty matter.

The liquid decanted from the solidified wax may afterwards be tested, to ascertain the purity of the base.

The solution of the sulphate may also be evaporated, and, by an examination of its crystalline form, or by means of chloride of platinum, it may be ascertained whether the base be soda or potash, or a mixture of the two.

As to the nature of the fatty substance, it is ascertained, with more or less certainty, by saturating the solution of the soap with tartaric acid, collecting the fat acids, and taking their point of fusion. It is possible, at least, by this to prove the identity or the absence of identity with the sample in the soap supplied; for instance, whether it is made from oil or tallow, &c. The odour developed by the fatty matter at the moment of the decomposition of the soap by acids assisted by heat will often indicate the nature of the fatty substance employed in its fabrication, or that at least of which the odour may prevail.

The soap is proved to contain an excess of fatty matter not saponified, by separating the fatty acids by means of hydrochloric acid, washing with hot distilled water, then combining them with baryta, and thoroughly washing the new compound with boiling water. The nonsaponified fatty matter is easily separated from the barytic soap by treating the mass with boiling alcohol, which dissolves the fatty substance. We can moreover assure ourselves that it has no acid reaction on moistened litmus paper, that it is fusible, and that it possesses the general character of a neutral fatty substance.

SOAPSTONE; see STRATITE.

SODA, Caustic soda (*Hydrate de soude, Fr.; Aetzatron, Germ.*); is an alkaline substance, used in chemical researches, in bleaching, and in the manufacture of soap. It is prepared by boiling a solution of crystallized carbonate of soda in 4 or 5 parts of water, with half its weight of recently slaked and sifted lime. At the end of half an hour, the vessel of iron, porcelain, or preferably silver, may be removed from the fire, and covered carefully, till the calcareous matter has settled into a solid magma at the bottom. The clear supernatant lye may be then decanted into bottles for use in the liquid state, or evaporated out of contact of air, till it assumes an oily appearance; then poured upon an iron or marble slab, broken into pieces, and put up in phials secured with greased stoppers or corks.

Caustic soda is a white brittle mass, of a fibrous texture, a specific gravity of 1.536, melting at a heat under redness, having a most corrosive taste and action upon animal matters, dissolving readily in both water and alcohol, attracting carbonic acid when exposed to the atmosphere, but hardly any water, and falling thereby into an efflorescent carbonate: it forms soaps with tallow, oils, wax, rosin; dissolves wool, hair, silk, horn, alumina, silica, sulphur, and some metallic sulphurets. It consists of 77.66 soda, and 22.34 water. A solution of caustic soda affords no precipitate with solution of chloride of platinum, or tartaric acid, as a solution of caustic potash never fails to do.

The following TABLE of the quantity of CAUSTIC SODA contained in LYES of different densities, has been given by Richter:—

| Spec. grav. | Soda per cent. | Spec. grav. | Soda per cent. | Spec. grav. | Soda per cent. | Spec. grav. | Soda per cent. |
|-------------|----------------|-------------|----------------|-------------|----------------|-------------|----------------|
| 1.00 | 0.00 | 1.12 | 11.10 | 1.22 | 20.66 | 1.32 | 29.96 |
| 1.02 | 2.07 | 1.14 | 12.81 | 1.24 | 22.58 | 1.34 | 31.67 |
| 1.04 | 4.02 | 1.16 | 14.73 | 1.26 | 24.47 | 1.35 | 32.40 |
| 1.06 | 5.89 | 1.18 | 16.73 | 1.28 | 26.33 | 1.36 | 33.08 |
| 1.08 | 7.69 | 1.20 | 18.71 | 1.30 | 28.16 | 1.38 | 34.41 |
| 1.10 | 9.43 | | | | | | |

Soda free from water can be obtained only by the combustion of sodium, which see.

On the 30th of June, 1838, Messrs. Dyars and Hemmings obtained a patent for manufacturing soda by the decomposition of sea-salt with sesquicarbonate or bicarbonate of ammonia. Equal parts of the chloride of sodium and sesquicarbonate are prescribed, being very nearly the equivalent decomposing proportions, and the ammonia salt is recommended to be added in powder to a saturated solution of the sea salt, and the mixture to be stirred, and then set aside till the mutual action and decomposition be effected. Having been employed to examine this process for a gentleman who wished to adopt it on a manufacturing scale, I obtained the following results. On

making the prescribed mixture in the cold, brisk effervescence takes place, because the quantity of carbonic acid combined with the ammonia is greater than the resulting soda can readily absorb, even to form its bicarbonate, and this extrication of gas carries off with it more or less ammonia, amounting, in carefully conducted experiments, to no less than 27 per cent. of the sesquicarbonate employed; though the magma deposited from the mixture was drained in vessels nearly close, and though the ammonia which adhered to it, as well as that in the drained mother liquors, was recovered by distillation in vessels connected with a Woulfe's apparatus. Moreover the utmost amount of soda-ash (not pure carbonate) which was obtained, was only 37.5 for 100 of sea salt used; whereas 90 of carbonate should result from 100 of the sea salt, with the above equivalent dose of sesquicarbonate of ammonia. This latter salt contains about one-half more carbonic acid than is required by the soda to become a carbonate. A good illustration of the loss of ammonia in a similar case is afforded by the decomposition of chloride of calcium in solution, by adding to it the equivalent dose of pulverised ammonia carbonate; viz. 56 of the former and 59 of the latter. The rapid extrication of the carbonic acid on making this mixture, causes such a waste of ammonia, that more of the sesquicarbonate must be afterwards introduced to complete the decomposition of the chloride; the stronger the solution of the chloride, the greater is the loss of ammonia.

In one of my experiments, where 3500 grains were employed = half a pound avoirdupois of each ingredient, the following were the products:—

| | Grains. |
|--|---------|
| 1. Ammonia recovered by distillation from the drained magma, equivalent in sesquicarbonate to - - - | 257 |
| 2. Ammonia as carbonate, from the remaining liquid, sucked into a vacuum apparatus and distilled - - - | 1509 |
| 3. Additional ammonia as carbonate, obtained from the cold mother liquors, by distillation with quick lime, and out of the sal ammoniac formed - - - | 775 |
| | 2541 |
| Sesquicarbonate employed - - - | 3500 |
| | 959 |
| Loss - - - | 959 |

or 27.4 per cent.

The product from this experiment in dry soda ash was only 1500 grains, which were found to contain only 1312 of pure carbonate, or 87.5 per cent. of the whole. Here is a deficiency of soda carbonate, upon the quantity of the chloride used, of no less than 58½ per cent., for only 1312 grains are obtained instead of 3150.

Subsequently a method occurred to me, whereby this process, elegant in a scientific point of view, might possibly be executed with advantage upon the commercial scale; but it would require a very peculiar apparatus, though not nearly so costly as what was erected by Mr. Cooper, under the direction of the patentees, at Battersea and in Brussels.

SODA, CARBONATE OF (*Kohlensaures natron*, Germ.); is the soda of commerce in various states, either crystallized, in lumps, or in a crude powder called soda-ash. It exists in small quantities in certain mineral waters; as, for example, in those of Seltzer, Seydschutz, Carlsbad, and the volcanic springs of Iceland, especially the Geyser; it frequently occurs as an efflorescence in slender needles upon damp walls, being produced by the action of the lime upon the sea salt present in the mortar. The mineral soda is the sesquicarbonate, to be afterwards described.

Of manufactured soda, the variety most antiently known is barilla, the incinerated ash of the *Salsola soda*. This plant is cultivated with great care by the Spaniards, especially in the vicinity of Alicant. The seed is sown in light low soils, which are embanked towards the sea shore, and furnished with sluices, for admitting an occasional overflow of salt water. When the plants are ripe, the crop is cut down and dried; the seeds are rubbed out and preserved; the rest of the plant is burned in rude furnaces, at a temperature just sufficient to cause the ashes to enter into a state of semi-fusion, so as to concrete on cooling into cellular masses moderately compact. The most valuable variety of this article is called *sweet barilla*. It has a grayish-blue colour, and gets covered with a saline efflorescence when exposed for some time to the air. It is hard and difficult to break; when applied to the tongue, it excites a pungent alkaline taste.

I have analysed many varieties of barilla. Their average quantity of free or alkali-metrical soda is about 17 per cent.; though several contain only 14 parts in the hundred, and a few upwards of 20. This soda is chiefly a carbonate, with a little sulphuret and sulphate; and is mixed with sulphate and muriate of soda, carbonate of lime, vegetable carbon, &c.

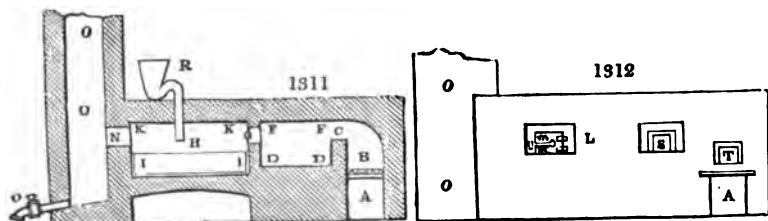
Another mode of manufacturing crude soda is by burning sea-weed into kelp. Formerly very large revenues were derived by the proprietors of the shores of the Scottish islands and Highlands, from the incineration of sea-weed by their tenants, who usually paid their rents in kelp; but since the tax has been taken off salt, and the manufacture of a crude soda from it has been generally established, the price of kelp has fallen extremely low.

The crystals of soda-carbonate, as well as the soda-ash of British commerce, are now made altogether by the decomposition of sea salt.

SODA MANUFACTURE.

The manufacture divides itself into three branches.—1. The conversion of sea salt, or chloride of sodium, into sulphate of soda. 2. The decomposition of this sulphate into crude soda, called *black balls* by the workman. 3. The purification of these balls, either into a dry white soda-ash or into crystals.

1. *The preparation of the sulphate of soda.*—Figs. 1311, 1312, 1313, represent the furnace for converting the muriate of soda into the sulphate. The furnace must be built interiorly of the most refractory fire-bricks, such as are used for glasshouses, but of the ordinary brick size; except the bridges *c*, *a*, *m*, which should be formed of one mass, such as what is called a Welsh lump. Δ is the ash pit; *n*, the grate; *c*, the first bridge, between the fire and the first calcining hearth *d*, *d*; *r*, *r*, is its roof; *a*, the second bridge, between the calcining hearth and the decomposing hearth *l*, *l*; the roof of which is *x*, *x*. This hearth *l*, *l*, is lined with a lead square pan, 5 or 6 inches deep, sloped at the back opening, in *fig. 1313*, marked *m'*; which deficient part of the upright side is filled up with two bricks placed one over the other, as shown at *n*, *n*, *fig. 1312*., and luted with clay, to confine the semi-liquid mass in the pan, *l*, *l*. Some

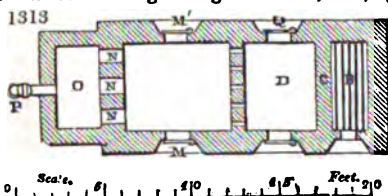


manufacturers make this pan 8 inches deep, and line its bottom and sides with bricks or siliceous sandstone, to protect the lead from the corrosive action of the acid. There are others who consider this precaution troublesome, as the points of the pan which become leaky are thereby concealed. In the roof of the decomposing hearth, one or two syphon funnels *n*, of lead, are inserted when the charge of acid (sulphuric) is to be poured down upon the salt in *l*, *l*, to save the risk of any annoyance from the fumes of the muriatic acid. *o*, *o*, is a chimney filled with round flint nodules, or coke, which are kept continually moist by the trickling of a streamlet of water upon the topmost layer. The muriatic gas meeting this descending film of water upon so extensive a surface becomes absorbed, and runs out below in a liquid form. When the acid is required in a somewhat concentrated state, this chimney should be made both high and capacious. Such a plan, moreover, is very valuable for abating the nuisance caused by the disengagement of the muriatic acid gas; which is otherwise apt to sterilize the surrounding vegetation.

A fire being kindled in the grate *n*, *figs. 1311*, and *1312*, 3 cwt. of salt in powder are to be thrown by a shovel into the pan *l*, through the door *m*, *fig. 1313*., or *m*, *m*, *fig. 1312*. Two hundred weight and a half of oil of vitriol, of specific gravity 1.844 having been diluted with from 25 to 30 per cent. of water, and well mixed, or 3 cwts. at 56° Baumé, are to be slowly poured in by the funnel, and diffused among the muriate of soda, by an occasional stir with an iron rake cased with sheet lead. Fumes of muriatic acid will now plentifully escape, and, passing up the condensing-shaft *o*, will flow down in the form of liquid spirit of salt, and escape by the stoneware stopcock *r*, into the pipe of a sunk cistern. The fire having been steadily kept up at a moderate degree, the chemical reaction will be tolerably complete in the course of two hours; but as this is relative to the nature of the fuel, and the draught of the furnace, no very precise rule in point of time can be laid down; but it is sufficient for this stage of the process, when the fumes cease to be very dense and copious, as may be ascertained by opening the door *m*, and looking in, or by the appearance at the top of the shaft *o*. Over the door *m'*, in the opposite side of the decomposing hearth, *fig. 1313*., there must be an arch or hood terminating in a smaller chimney, 15 or 20 feet high, for the ascent of the muriatic va-

pours, when the charge is drawn or run out of the hearth, and allowed to fall into a square shallow iron tray, placed on the ground at the back of the furnace. For this discharge, the two bricks which serve as stoppers to that orifice must be unluted and removed.

As soon as that charge is taken out, (the fire being meanwhile checked by opening the door τ , *fig.* 1312., and shutting partially the ash-pit opening at Δ .) a fresh charge must be introduced as above described. The nearly decomposed saline matter during the second charging of the hearth τ , will have grown cool and concrete. It must be shovelled into the calcining hearth ν , *fig.* 1311., by the back door q , *fig.* 1313., where it will receive a higher degree of heat; and, by the expulsion of the remaining part of



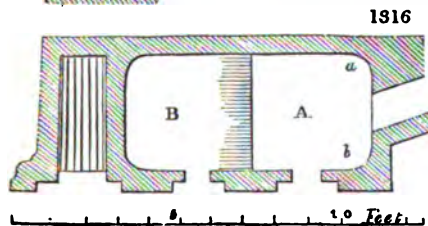
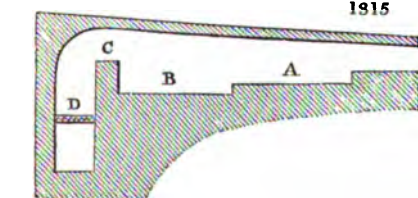
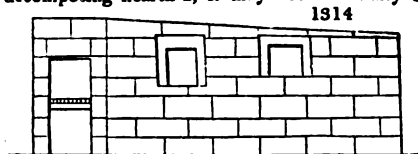
the muriatic acid, it will become a perfect sulphate of soda. It should be finally brought into a state of semi-fusion. When a sample of it, taken out on the end of the rake or trowel-shaped scraper, emits no fumes, the conversion is accomplished.

From 3 cwts. of common salt, or muriate of soda, rather more than $3\frac{1}{2}$ cwts. of perfect sulphate should be

obtained, quite free from metallic impurity.

The next step is the conversion of the sulphate into a crude soda.

One of the most improved soda furnaces is that, employed in a few factories, represented in *figs.* 1314, 1315, and 1316. In the section *fig.* 1315., there are two hearths in one furnace, the one elevated above the level of the other by the thickness of a brick, or about 3 inches. Δ is the preparatory shelf, where the mixture to be decomposed is first laid in order to be thoroughly heated, so that when transferred to the lower or decomposing hearth ν , it may not essentially sizzle it, and throw back the operation,



c is the fire-bridge, and ν is the grate. In the horizontal section, or ground plan, *fig.* 1316., we see an opening in the front corresponding to each hearth. This is a door, as shown in the side view or elevation of the furnace, *fig.* 1314.; and each door is shut by an iron square frame filled with a fire-tile or bricks, and suspended by a chain over a pulley fixed in any convenient place. See *PRCOAL*, *COKING* *OR*. The workman, on pushing up the door lightly, makes it rise, because there is a counterweight at the other end of each chain, which balances the weight of the frame and bricks. In the ground plan, only one smoke-flue is shown; and this construction is preferred by many manufacturers; but others choose to have two flues, one from each shoulder, as at a , b ; which two flues afterwards unite in one vertical chimney, from 25 to 40 feet high; because the draught of a soda furnace must be very sharp. Having sufficiently explained the construction of this improved furnace, I shall now proceed to describe the mode of making soda with it.

The materials with which the sulphate is decomposed into a rough carbonate of soda are chalk or ground limestone, and ground coal or charcoal. The proportions in which these three substances are mixed, influence in a remarkable degree the success of the decomposing process. I have known a false proportion introduced and persevered in at a factory, with the most prejudicial effect to the product; the soda-ash produced being in small quantity relatively to the sulphate employed, and being much charged with sulphur. After very numerous trials which I have made on the great scale, and many inquiries at the most successful soda-works, both in this country and abroad, I am warranted to offer the following proportions as the most profitable: —

Sulphate of soda, 100 parts; carbonate of lime (chalk or limestone), from 110 to 120 parts; if pure, 110; if a little impure or damp, 120; pitcoal, 50 parts.

These materials must be separately ground by an edge-stone mill, and sifted into a tolerably fine powder. They must be then very carefully mixed. Attention to these particulars is of no little importance to the success of the soda process.

One hundred parts or pounds of sulphate of soda are equivalent to 75 parts of carbonate, and when skillfully decomposed, will generally yield fully 70 pounds. A charge for the decomposing furnace with the preparatory shelf should not exceed 200 lbs., or perhaps 180; therefore if 75 pounds of ground sulphate of soda, with 80 pounds of chalk or limestone (ground), and 37 pounds of ground coal, be well mixed, they will constitute one charge. This charge must be shovelled in upon the hearth *A*, or shelf of preparation, (*fig.* 1315.); and whenever it has become hot (the furnace having been previously brought to bright ignition), it is to be transferred to the decomposing hearth or laboratory *B*, by an iron tool, shaped exactly like an oar, called the spreader. This tool has the flattened part from 2 to 3 feet long, and the round part, for laying hold of and working by, from 6 to 7 feet long. Two other tools are used; one, a rake, bent down with a garden hoe at the end; and another, a small shovel, consisting of a long iron rod terminated like a piece of iron plate, about 6 inches long, 4 broad, sharpened and tipped with steel, for cleaning the bottom of the hearth from adhering cakes or crusts. Whenever the charge is shoved by the sliding motion of the oar down upon the working hearth, a fresh charge should be thrown into the preparation shelf, and evenly spread over its surface.

The hot and partially carbonized charge being also evenly spread upon the hearth *B*, is to be left untouched for about ten minutes, during which time it becomes ignited, and begins to fuse upon the surface. A view may be taken of it through a peep-hole in the door which should be shut immediately, in order to prevent the reduction of the temperature. When the mass is seen to be in a state of incipient fusion, the workman takes the oar and turns it over breadth by breadth in regular layers, till he has reversed the position of the whole mass, placing on the surface the particles which were formerly in contact with the hearth. Having done this he immediately shuts the door, and lets the whole get another decomposing heat. After five or six minutes, jets of flame begin to issue from various parts of the pasty-consistenced mass. Now is the time to incorporate the materials together, turning and spreading by the oar, gathering them together by the rake, and then distributing them on the reverse part of the hearth; that is, the oar should transfer to the part next the fire-bridge the portion of the mass lying next the shelf, and *vice versa*. The dexterous management of this transposition characterizes a good soda-furnacer. A little practice and instruction will render this operation easy to a robust clever workman. After this transposition, incorporation, and spreading, the door may be shut again for a few minutes, to raise the heat for the finishing off. Lastly, the rake must be dexterously employed to mix, shift, spread, and incorporate. The jets, called *candles*, are very numerous, and bright at first; and whenever they begin to fade, the mass must be raked out into cast-iron moulds, placed under the door of the laboratory to receive the ignited paste.

One batch being thus worked off, the other, which has laid undisturbed on the shelf, is to be shoved down from *A* to *B*, and spread equally upon it, in order to be treated as above described. A third batch is then to be placed on the shelf.

The article thus obtained should contain at least 22 per cent. of real soda, equivalent to 37 per cent. of dry carbonate, or to 100 of crystals. A skillful workman can turn out a batch from three quarters of an hour to an hour, producing a perfect carbonate, which yields on solution an almost colourless liquid, nearly destitute of sulphur, and containing hardly any undecomposed sulphate.

In some soda works, where the decomposing furnace is very large, and is charged with a ton of materials at a time, it takes two men to work it, and from five to six hours to complete a batch. Having superintended the operation of the above-described small furnace, and examined its products, I feel warranted to recommend its adoption.

The following materials and products show the average state of this soda process:—

Materials—100 parts of sulphate of soda, ground, equivalent to 75 of carbonate; 110 of chalk or ground limestone; 55 of ground coal: in the whole 265.

Products—168 parts of crude soda, at 33 per cent. = 55.5 of dry carbonate.

Or, $\left\{ \begin{array}{l} 130 \text{ — crystals of carbonate of soda} = 48 \text{ of dry carbonate; and} \\ 100 \text{ — insoluble matter.} \end{array} \right.$

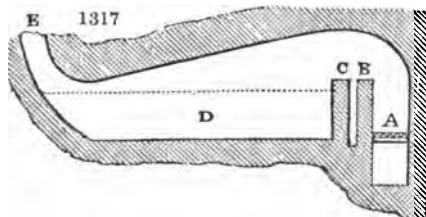
But these products necessarily vary with the skill of the workman.

In another manufactory the following proportions are used:—Six stones, of 14 lbs. each, of dry ground sulphate of soda, are mixed with 3 of chalk and 3 of coal. This mixture weighing $1\frac{1}{2}$ cwt., forms a batch, which is spread upon the preparation shelf of the furnace (*figs.* 1315. and 1316.), as above described, and gradually heated to incipient ignition. It is then swept forwards to the lower area *B*, by the iron oar, and spread evenly by the rake. Whenever it begins to soften under the rising heat of the

laboratory (the side doors being meanwhile shut), the mass must be laboriously turned over and incorporated; the small shovel, or paddle, being employed to transfer, by the interchange of small portions at a time, in rapid but orderly succession, the whole materials from the colder to the hotter, and from the hotter to the colder parts of the hearth. The process of working one batch takes about an hour, during the first half of which period it remains upon the preparation shelf. The average weight of the finished ball is 1 cwt., and its contents in alkalimetical soda are 33 pounds.

Where the acidulous sulphate of iron from pyrites may be had at a cheap rate, it has been long ago employed, as at Hurllett in Scotland, instead of sulphuric acid for decomposing the chloride of sodium. Mr. Turner's process of preparing soda, by decomposing sea salt with litharge and quicklime, has been long abandoned, the resulting patent yellow or sub-chloride of lead having a very limited sale.

2. *The extraction of pure soda from the crude article.*—The black balls must be broken into fragments, and thrown into large square iron cisterns, furnished with false bottoms of wooden spars; when the cisterns are nearly full of these lumps, water is pumped in upon them, till they are all covered. After a few days, the lixiviation is effected, and the lye is drawn off either by a syphon or a plug-hole near the bottom of the cistern and run into evaporating vessels. These may be of two kinds. The surface-evaporating furnace, shown in *fig. 1317.*, is a very



admirable invention for economizing vessels, lime, and fuel. The grate *A*, and fire-place, are separated from the evaporating laboratory *B*, by a double fire-bridge *B, C*, having an interstitial space in the middle, to arrest the communication of a melting or igniting heat towards the lead-lined cistern *D*. This cistern may be 8, 10, or 20 feet long, according to the magnitude of the soda-work, and 4 feet or more wide. Its depth should be about 4 feet. It consists of sheet-lead, of about 6 pounds weight to the square foot, and it is lined with one layer of bricks, set in roman or hydraulic cement, both along the bottom and up the sides and ends. The lead comes up to the top of *C*, and the liquor, or lye, may be filled in to nearly that height. Things being thus arranged, a fire is kindled upon the grate *A*; the flame and hot air sweep along the surface of the liquor, raise its temperature there rapidly to the boiling point and carry off the watery parts in vapour up the chimney *Z*, which should be 15 or 20 feet high, to command a good draught. But, indeed, it will be most economical to build one high capacious chimney stalk, as is now done at Glasgow, Manchester, and Newcastle, and to lead the flues of the several furnaces above described into it. In this evaporating furnace the heavier and stronger lye goes to the bottom, as well as the impurities, where they remain undisturbed. Whenever the liquor has attained to the density of 1.3, or thereby, it is pumped up into evaporating cast-iron pans, of a flattened somewhat hemispherical shape, and evaporated to dryness while being diligently stirred with an iron rake and iron scraper.

This alkali gets partially carbonated by the above surface-evaporating furnace, and is an excellent article.

When pure carbonate is wanted, that dry mass must be mixed with its own bulk of ground coal, sawdust or charcoal, and thrown into a reverberatory furnace, like *fig. 1316.*, but with the sole all upon one level. Here it must be exposed to a heat not exceeding 650° or 700° F.; that is, a little above the melting heat of lead; the only object being to volatilize the sulphur present in the mass, and carbonate the alkali. Now, it has been found, that if the heat be raised to distinct redness, the sulphur will not go off, but will continue in intimate union with the soda. This process is called *calking*, and the furnace is called a *colker furnace*. It may be 6 or 8 feet long, and 4 or 5 feet broad in the hearth, and requires only one door in its side, with a hanging iron frame filled with a fire-tile or bricks, as above described.

This carbonating process may be performed upon several cwts. of the impure soda, mixed with sawdust, at a time. It takes three or four hours to finish the desulphuration; and it must be carefully turned over by the oar and the rake, in order to burn the coal into carbonic acid, and to present the carbonic acid to the particles of caustic soda diffused through the mass, so that it may combine with them.

When the blue flames cease, and the saline matters become white, in the midst of the coaly matter, the batch may be considered as completed. It is raked out, and when cooled, lixiviated in great iron cisterns with false bottoms, covered with mats. The watery solution being drawn off clear by a plug-hole, is evaporated either to dryness, in hemispherical cast-iron pans, as above described, or only to such a strength that it

shows a pellicle upon its surface, when it may be run off into crystallizing cisterns of cast iron, or lead-lined wooden cisterns. The above dry carbonate is the best article for the glass manufacture.

Crystallized carbonate of soda, contains $62\frac{1}{2}$ per cent. of water. The crystals are colourless transparent rhomboids, which readily effloresce in the air, and melt in their own water of crystallization. On decanting the liquid from the fused mass, it is found that one part of the salt has given up its water of crystallization to another. By evaporation of that fluid, crystals containing one-fifth less water than the common carbonate are obtained. These do not effloresce in the air.

Mineral soda, the sesquicarbonate (*Anderthalb kohlen-saures natron*, Germ.); is found in the province of Sukena, in Africa, between Tripoli and Fezzan. It forms a stratum no more than an inch thick, just below the surface of the soil. Its texture is striated crystalline, like fibrous gypsum. Several hundred tons of it are collected annually, which are chiefly consumed in Africa. This species of soda does not effloresce like the Egyptian, or the manufactured soda crystals, owing to its peculiar state of composition and density. It was analyzed by Klaproth, under its native name of *trona*, and was found to consist, in 100 parts, of — soda, 37; carbonic acid, 38; sulphate of soda, 2.5; water, 22.5, in 100.

This soda is, therefore, composed of—3 atoms of carbonic acid, associated with 2 atoms of soda, and 4 of water; while our commercial soda crystals are composed of—1 atom of carbonic acid, 1 atom of soda, and 10 atoms of water.

There are six natron lakes in Egypt. They are situated in a barren valley, called Bahr-bela-ma, about thirty miles to the west of the Delta.

There are natron lakes also in Hungary, which afford in summer a white saline efflorescent crust of carbonate of soda, mixed with a little sulphate.

There are several soda lakes in Mexico, especially to the north of Zacatecas, as also in many other provinces. In Columbia, 48 English miles from Merida, mineral soda is extracted from the earth in great abundance, under the name of *wrao*.

Bicarbonate of soda (*Doppelt kohlen-saures natron*, Germ.); is prepared, like bicarbonate of potassa, by transmitting carbonic acid gas through a cold saturated solution of pure carbonate of soda, till crystalline crusts be formed. The bicarbonate may also be obtained in four-sided tables grouped together. It has an alkaline taste and reaction upon litmus paper, dissolves in 13 parts of cold water, and is converted by boiling water into the sesquicarbonate, with the disengagement of one fourth of its carbonic acid. It consists of—37 of soda, 52.35 carbonic acid, and 10.65 water.

SODA MANUFACTURE IMPROVED. In carrying on this process on the great scale, it was long customary to permit the escape of the hydrochloric acid in the decomposition of the muriate of soda by sulphuric acid as a waste product; and this is done in some localities at the present day. But independently of the actual loss thus caused, the injurious action of the acid fumes upon every form of vegetation, for many miles around the manufactory, has compelled the maker of soda to condense this hydrochloric acid, by passing it through flues filled with coke; over the cavernous surface of which a small stream of water constantly flows. In this way, a large quantity of liquid muriatic acid is procured, which, though too impure for many of the ordinary requirements of the arts, is yet admirably adapted for the generation of chlorine, and the subsequent manufacture of chloride of lime. The total worth of this waste product may be gathered from the fact, that in one set of large soda works near Glasgow, sufficient muriatic acid is collected to yield 8,000 tons of chloride of lime per annum, and yet this scarcely represents one-twentieth of the soda manufacture of Great Britain. Having in this way obtained a quantity of sulphate of soda, the soda maker now proceeds to his next operation. Here, however, it may be as well to remark, that the sulphate of soda in question is not nearly pure, but usually contains from five to ten per cent. of common salt, which has escaped decomposition in the sulphate furnace; as it is more economical to leave a small excess of chloride of sodium than to add a superfluity of sulphuric acid, — since this latter is vastly more expensive than the former; and the presence of common salt is rather beneficial than otherwise during the subsequent process. To convert this impure sulphate of soda into carbonate of soda, it is mixed in about equal proportions with chalk or carbonate of lime, and small coals, all in a state of rough powder. The mixture, merely thrown together with shovels, is projected into a reverberating furnace called the ball-furnace, where it is stirred about with a long iron paddle, until it undergoes an imperfect fusion; and long jets of yellow flame, technically called "candles," burst out from various parts of the mass, which, for an ordinary charge of 3 cwt. or 4 cwt., will require about three hours. The whole is then raked out, and allowed to cool, the furnace being supplied, as before, with a fresh charge of materials. The product of this operation is known as ball-soda, and it consists of carbonate of soda, sulphuret of sodium, chloride of sodium, undecomposed sulphate of soda, carbonate of lime, sulphuret of calcium, and carbon of coke. We have had an opportunity of examining several

specimens from the largest manufactories in the kingdom, and find no great difference in the results. The average composition appears to be as under :—

| | | | | | | | |
|---------------------|---|---|---|---|---|---|-------|
| Soda | - | - | - | - | - | - | 19.80 |
| Carbonic acid | - | - | - | - | - | - | 9.24 |
| Sulphuret of sodium | - | - | - | - | - | - | 2.64 |
| Chloride of sodium | - | - | - | - | - | - | 5.22 |
| Sulphate of soda | - | - | - | - | - | - | 6.10 |
| Sulphate of calcium | - | - | - | - | - | - | 29.40 |
| Carbonate of lime | - | - | - | - | - | - | 21.70 |
| Coke | - | - | - | - | - | - | 5.90 |
| | | | | | | | 100 |

We shall describe the mode of analyzing this compound a little further on, but at this moment it will be more advantageous to pursue the remainder of the operation for procuring carbonate of soda from the cooled product of the ball-furnace. This substance, under the name ball-soda, is roughly broken to pieces, and piled up in a large iron tank, provided with a false bottom or grating, and having an aperture near the bottom. When the tank is full, the aperture near the bottom is plugged up, and hot water run upon the ball-soda to within an inch or two of the top of the tank. The whole is allowed to remain for several hours; by which the salts of soda, consisting, as we have seen, of carbonate and sulphate of soda, with the chloride and sulphuret of sodium, are dissolved; the plug is then withdrawn, and the soluble matters are allowed to flow away from the carbonate of lime, sulphuret of calcium, and coke, which are insoluble. Upon these latter a fresh portion of hot water is poured, so as thoroughly to remove the soda salts; and this last solution is commonly applied to a quantity of new ball-soda, in order to economize the cost of evaporation. The first fluid from the tank is conducted at once into a reverberatory furnace, where the water is rapidly expelled, and a dry saline product obtained. This is immediately transferred to what is called the carbonating furnace, where the sulphuret of sodium is partly decomposed by the carbonic acid of the furnace, and partly reconverted into sulphate of soda by the oxygen of the air.

Meantime, the portion of soda existing in the mass as caustic soda becomes carbonated by the carbonic acid of the fire; and hence the name of this particular furnace. Having been kept at a dull red heat, but short of that required for actual fusion, the whole is withdrawn and cooled; after which, it is boiled in water, and the concentrated solution run off into shallow coolers to crystallize. As the saline constituents now consist almost entirely of carbonate of soda, with a little sulphate of soda and chloride of sodium, the former salt crystallizes and becomes solid; leaving the two latter, with a portion of carbonate of soda, in solution. The crystals are taken out, dried, and packed for the market; whilst the residuary solution is evaporated to dryness, and the result sold under the name of soda-ash: though this name is sometimes also applied to the direct product of the carbonating furnace. The nature of the decomposition which takes place in the ball-furnace may be very correctly inferred from the composition of the products thence ensuing. We have seen that the primary mixture is composed of sulphate of soda, carbonate of lime, and carbon. On exposing these to a red heat, sulphuret of sodium is generated, which immediately acts upon the carbonate of lime, producing sulphuret of calcium and carbonate of soda. As, however, during the reduction of the sulphate of soda, part of the carbonate of lime is rendered caustic by the expulsion of its carbonic acid, this caustic lime makes its appearance in the ball-soda tank, and converts a portion of the carbonate of soda into caustic soda; hence the necessity for the carbonating furnace, which is, moreover, useful in destroying the sulphuret of sodium.

We shall now proceed to describe the mode of analyzing ball-soda; after which it will be necessary to review the whole process of soda-making, with a view to the possibility of improvement.

Having selected a fair sample of the ball-soda to be examined, this must be reduced to an extremely fine powder, and a given weight of it — say 100 grains, digested in two ounces of hot water for ten or fifteen minutes; then throw the whole on a filter, and wash this gradually with 3 ounces of boiling water, taking care to add these washings to the first liquid which passes through the filter. The filter, with its insoluble contents, may now be set in a warm place to dry. Meanwhile, the clear solutions being mixed, are to be tested with finely powdered carbonate of lead, until this ceases to be blackened: when this occurs, the heavy black precipitate of sulphuret of lead is allowed to settle, and the clear colourless solution is poured off into a porcelain basin. This being gently heated, is now to be thrown upon the sulphuret of lead; and, when this has again settled, the clear fluid must be withdrawn and added to that in the porcelain basin. This, being gently heated, must next be treated by a dilute acid of a determinate strength (see ALKALIMETRY), until litmus paper, on being dipped into it, becomes slightly reddened;

when the amount of soda present, or of carbonate of soda, may be inferred, in the usual way, from the composition of dilute acid. The sulphuret of lead remaining from this operation is now to be supersaturated with acetic acid, and slightly heated, for the purpose of removing from it any excess of carbonate of lead that may have been added in the first instance; the sulphuret of lead must then be well washed with hot water, dried and weighed. Every 120 grains represent 40 grains of sulphuret of sodium, and for this 32 grains of soda must be deducted from the result of the acidulous assay. The insoluble matter remaining on the filter is now to be transferred to a double-necked bottle provided with a bent tube, for passing the evolved gases through a solution of the acetate of lead in weak acetic acid. This insoluble matter consists of carbonate of lime, sulphuret of calcium, and coke; if, therefore, diluted muriatic acid is poured upon it, the two former substances will be decomposed with the evolution of carbonic acid and sulphuretted hydrogen, the latter of which is absorbed by the acidulous solution of the acetate of lead; whilst the carbonic acid passes on and escapes. In combining with the solution of acetate of lead, the sulphuretted hydrogen gives rise to the formation of sulphuret of lead, which, being well washed with hot water, then dried and weighed, gives the amount of sulphuret of calcium existing in the residue: for every 120 grains of sulphuret of lead indicate 34 of sulphuret of calcium. The fluid in the two-necked flask consists of chloride of calcium, with the coke of the ball-ash. This must, therefore, be thrown on a filter, and well washed with hot water, and dried: the coke may then be separated and weighed. As from the existence of carbonate of soda in the first solution neither lime nor its sulphate could exist in the insoluble matter, if this had been weighed previously to these latter experiments, the difference in weight, after deducting the sulphuret of calcium and the coke, will be that of the carbonate of lime; and this, under the circumstances, is sufficiently correct in moderately skilful hands. It now remains, therefore, only to determine the quantity of chloride of sodium and sulphate of soda present in the ball-soda. For this purpose, 100 grains of the finely powdered compound are to be treated exactly as before, with hot water and carbonate of lead. In this case, however, the resulting alkaline solution must be supersaturated with pure nitric acid, and to this an excess of nitrate of silver must be added, and the mixture warmed. A dense coagulated precipitate will fall, from which the clear solution being poured off into a proper vessel, the precipitate is to be washed with a little boiling distilled water, and the washings added to the clear solution before mentioned. The precipitate being now well dried in a dark place must be weighed; and for every 144 grains of this precipitate, 60 grains of chloride of sodium must be assumed. To the clear solution resulting from this operation, an excess of nitrate of baryta must be thrown in, and the mixture slightly heated as before, and then thrown on a previously weighed filter. This filter, when the solution has passed, is to be repeatedly washed with boiling distilled water, until this fluid passes through pure; the filter is then to be well dried and weighed, to ascertain its increase of weight. This increase is due to the presence of sulphate of baryta, for every 117 grains of which 72 grains of sulphate of soda must have existed in the portion of ball-soda examined. To determine the amount of carbonic acid combined with the soda, a given quantity (and for this purpose 50 grains is enough) of the finely-powdered ball-soda must be lixiviated as before, and the clear solution boiled down to dryness with an excess of pure peroxide of manganese, — the whole being at last slightly heated over the fire. By the action of the manganese at this heat, the sulphuret of sodium is converted into sulphate of soda; and if the soda salts be now dissolved in a small quantity of water, and the solution placed in a proper flask, provided with a bent tube containing chloride of calcium, to arrest moisture, the carbonic acid may be expelled by a known weight of diluted sulphuric acid; and presuming the flask and the vessel containing the dilute acid to have been carefully weighed before and after the experiment, the loss gives at once the weight of the carbonic acid united to the soda. This appears never to be equivalent to the amount of soda. There is a circumstance connected with the lixiviation of ball-ash, on the large scale, which has probably escaped the attention of manufacturers, but is of considerable importance towards securing a successful result. The general practice is to employ hot water for dissolving out the soda salts, and to retain this solution in contact with the insoluble residue for several hours. Theoretically, this is incorrect, and, practically, we have found it injurious. Sulphuret of calcium, though an insoluble salt, is not absolutely so; and the moment this substance in solution comes in contact with carbonate of soda, double decomposition ensues, attended with the production of carbonate of lime and sulphuret of sodium — a process exactly the reverse of that which happens under the influence of a red heat, and of which, in chemistry, there are many other examples. Thus it constantly happens that sulphuret of sodium is found in the lixiviated products of ball-soda. If, however, cold water be employed, and the contact of the carbonate of soda with the sulphuret of calcium be considerably diminished, as with great ease may be done, by coarsely powdering the ball-soda, instead of employing it in lumps, then the clear solution is almost entirely

free from sulphuret or sodium, and is devoid of colour; whereas, by the hot water process, this fluid is invariably of a dirty-green hue, and has an offensive odour of sulphuretted hydrogen. Now, remembering that the sulphuret of sodium is a dead loss to the manufacturers, and moreover diminishes the market value of the rest of his produce, the question of hot or cold water, with or without proper pulverization of the ball-soda, is in reality a very important affair.

By the afore-recited analysis, it appears that, out of 22·91 parts of soda, 2·11 were combined with sulphuretted hydrogen; this is at the rate of more than 9 per cent., and would form a handsome addition to the usual profits of the manufacturer. One of the great drawbacks upon the manufacture of soda is the difficulty of disposing of the insoluble residue. This contains more than half its weight of sulphuret of calcium, a substance which, in the wet state, is rapidly decomposed by the carbonic acid of the air with the evolution of sulphuretted hydrogen gas, and, if moderately dry, is almost certain to take fire by contact with the atmosphere, and thus taint the surrounding neighbourhood with its sulphurous emanations. It is extremely likely that this refuse product would answer the purpose of lime for all agricultural uses, and also furnish sulphur to such crops as require this element,—plants of the natural order crucifera for example. Gas lime is in great measure a perfectly analogous compound, and this is largely used in some of our inland counties, and found to be an extremely beneficial application. The refuse of soda-works has not, however, assumed a similarly favourable character amongst farmers; and it is now a real and growing nuisance to the manufacturer of soda.

Perhaps, after all, it would be better to think of devising a remedy for preventing the formation of this residuum than seek an outlet for its consumption. With this view, we venture to lay the following process before our readers, embracing within itself what may be termed the perfection of soda-making. How far on a large scale the difficulties might increase beyond the advantage, our experience will not enable us to judge; but in a moderate way, the whole of the operations have been consecutively tried and found satisfactory. The key to the ultimate decomposition turns upon a circumstance in chemistry which is, for the most part, but little known: and that is, the ease with which the hydrosulphates of the alkalis, when slightly moistened, are converted into carbonates by the action of carbonic acid. If much water be present, the decomposition goes on languidly, and is never perfect; if too little water, the decomposition is speedily arrested by the formation of a crust of alkaline carbonate. It is the middle state, between these two conditions, which must be aimed at, and which we will now proceed to describe in a condensed account of the proposed method:—With a precisely similar form of apparatus to that now in use for preparing sulphate of soda, and condensing muriatic acid, but with some little additional care, a given weight of common salt might be converted into sulphate of soda, and the whole of its muriatic condensed, which, of course, would be an exact equivalent of the soda present in the sulphate of soda; that is to say, 60 parts of chloride of sodium and 49 parts of pure hydrated sulphuric acid would produce 72 parts of dry sulphate of soda, and 37 parts of anhydrous muriatic acid. These relative proportions must be borne in mind to facilitate the comprehension of the ultimate process. Having placed the muriatic acid on one side for the present, we proceed to convert the sulphate of soda into sulphuret of sodium, by mixing it with its own weight of coarsely powdered coal or coke, and exposing the mixture to a red heat in a proper furnace for an hour or two. At this temperature the carbon of the coal unites with the oxygen of the sulphate of soda, and flies off as carbonic oxide gas, leaving the sulphur and sodium combined together as sulphuret of sodium, with the excess of small coal or coke employed. As soon as this mixture is sufficiently cool, it should be broken or pounded into a rough powder, which must now be moistened with water to the consistence of damp sand, or until a handful tightly squeezed in the hand adheres together as a ball or lump. When this is the case, the whole should be placed in a vessel, or set of vessels, similar to those used for the purification of coal-gas by means of slaked lime. It is best to have four of these vessels, three of which are to be continually in action. The moistened sulphuret of sodium or hydrosulphate of soda being duly arranged, a stream of carbonic acid is made to traverse the three vessels in action, by which the hydrosulphate of soda is converted into carbonate of soda, and the hydrosulphuric acid, or sulphuretted hydrogen, being expelled in a pure state, may readily be burnt at a jet in a common sulphuric acid chamber, with the usual dose of nitrate of soda for its acidification. Thus the quantity of sulphuric acid originally employed to decompose the salt would be constantly regenerated and used over again. The requisite carbonic acid would also be easily procured by acting upon chalk with the muriatic acid condensed in the first instance. Some fear might seem to be justified by the possibility of the carbonic acid passing off with the sulphuretted hydrogen; but, under common care, guided by experience, this could never occur. So long as any considerable quantity of hydrosulphate of

soda remained in the second and third vessels, no carbonic acid could pass through them; and, as soon as No. 1. was discovered to be saturated, this might be thrown out of action, and the fourth vessel employed; meanwhile No. 1. might be emptied, and refilled with fresh material to follow on after No. 4., when the second vessel was saturated; and thus continually.

In commencing this description we assumed at first 60 parts of common salt, and 49 of hydrated sulphuric acid, which would give 72 of sulphate of soda and 37 of muriatic acid. Now these 72 of sulphate of soda would form 49 of hydrosulphate of soda; whilst 37 of muriatic acid, by acting upon chalk, would furnish exactly sufficient carbonic acid to convert the 49 of hydrosulphate of soda into 54 of carbonate of soda, and 17 of sulphuretted hydrogen. But this sulphuretted hydrogen, when carefully consumed, would regenerate 49 parts of sulphuric acid, to be again used in decomposing 60 parts of common salt, and so on in continual rotation. The only resulting products would, therefore, be carbonate of soda and muriate of lime; the sulphuric acid merely performing the part of a vehicle for effecting the decomposition. As regards the economy of this process, it seems in no way doubtful; and, viewed in a practical light, there is no insurmountable or even probable difficulty in the way of its immediate and successful adoption: necessarily there would arise some loss from waste and commercial impurities; but the scope for speculative industry is very large, and all risk of much loss by failure may be reduced within reasonable limits by beginning upon a very small scale at first, and extending the manufacture in proportion to the success of the enterprise. The huge mountains of sulphuret of calcium which arise under the present system, and contaminate the air with their pestiferous exhalations, proclaim too obviously that a change is needed; and some idea of the enormous mass of matter thus daily accumulating may be gathered from the fact, that one soda-maker alone admitted to us that his average production of this residue was at the rate of 400 tons per week, or 20,800 tons per annum.—*Mr. Lewis Thompson.*

SODA-WATER is the name given to water containing a minute quantity of soda, and highly charged with carbonic acid gas, whereby it acquires a sparkling appearance, an agreeable pungent taste, an exhilarating quality, and certain medicinal powers. It constitutes a considerable object of manufacture in this kingdom. The following figure represents, I understand, the best system of apparatus for preparing it. A very dilute solution of soda is put into the globular vessel *n*, and the carbonic acid gas is forced into it from the gasometer *z*, by means of the powerful pump-work, as will be understood from the subjoined explanation.

The same apparatus may serve for making any species of aerated water, in imitation of any natural spring. All that is necessary for this purpose, is to put into the cistern *q* the neutro-saline matter, earths, metallic oxides, pure water, &c., each in due proportion, according to the most accredited analysis of the mineral water to be imitated, to agitate that mixture, to suck it into the condenser *h*, through the pipe *z*, and then to impregnate it to the due degree, by pumping in the appropriate gas, previously contained in the gasometer *r*.

Thus, to make Seltzer water, for each 12 pounds troy, = 69,120 grains, or 1 gallon imperial very nearly, take 55 grains of dry carbonate of soda, 17 of carbonate of lime, 18 of carbonate of magnesia, $3\frac{1}{2}$ of subphosphate of alumina, 3 of chloride of potassium, 155 of chloride of sodium, and 3 of finely precipitated silica. Put these materials into the cistern *q*, and charge the gasometer *r* with 353 cubic inches of carbonic acid gas. Then work the machine by the handle of the wheel *x*, as explained below, and regulate the introduction of the liquid and the gas in aliquot portions; for example, if the condenser *h* admits half a gallon of water at a time, that quantity of liquid should be charged with 176 cubic inches of the gas, being one half of the whole quantity. The sulphuretted mineral waters may be imitated in like manner, by taking the proportions of their constituents, as given in Table II. of WATERS, MINERAL.

At page 21. of vol. x. of the conjoined series of Newton's Journal, the patent apparatus of Mr. F. C. Bakewell, of Hampstead, for making soda water, is well described with illustrative figures. The patent was obtained in March, 1832, but how far it has been introduced into practice I have not heard. Its arrangement discovers ingenuity, but it seems less likely to prove durable than the patent apparatus of Mr. Tyler, which *fig.* 1320. in the following page represents according to his latest specification. *A*, is the gas generator, where the chalk and sulphuric acid are mixed; *z*, the gasometer; *c*, the soda-water pump, for forcing the gas; *n*, the condenser; *x*, the solution (of soda) pan; *r*, the bottling cork; *g*, the acid bottle, at the right hand shoulder of *A*; *h*, the wheels, for working the agitator in the condenser; *i*, the pipe, for conveying the gas to the pump; *k*, pipe for conveying the solution to the pump; *L*, cocks for regulating the admission of the gas into solution; *m*, drawing-off pipe leading to the bottling cork; *v*, the forcing pipe from the pump to the condenser.

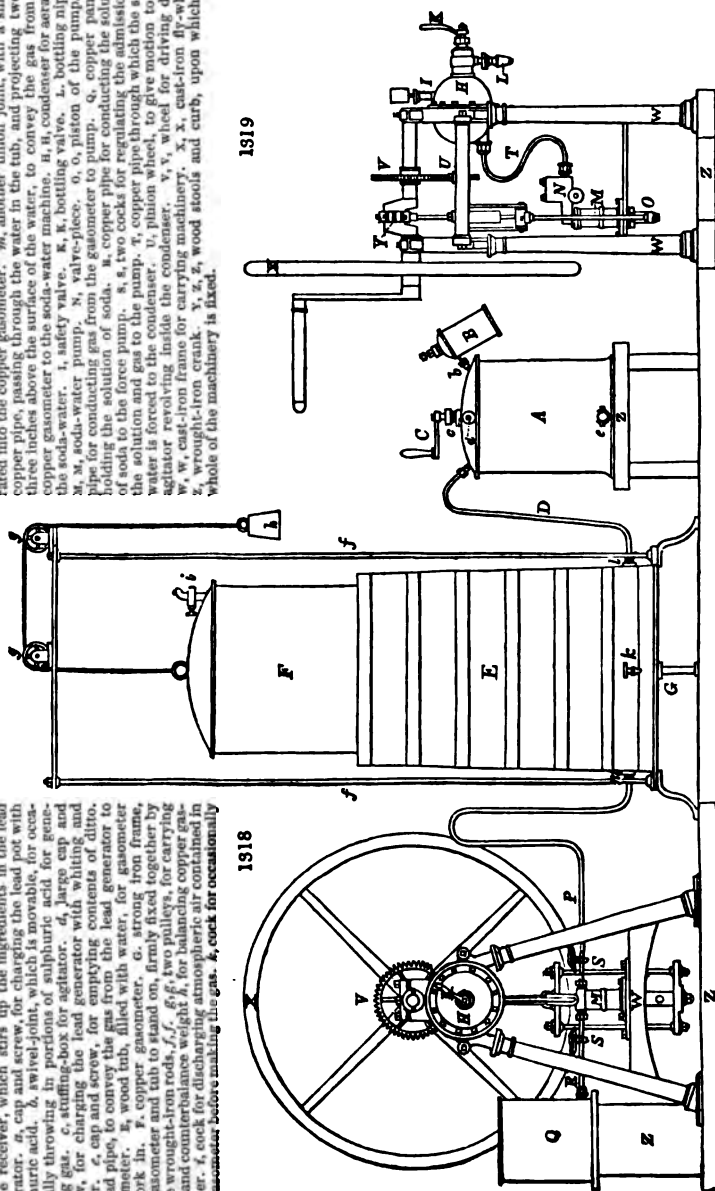
The vessel in which the soda water is condensed is lined with silver in order to resist corrosion.

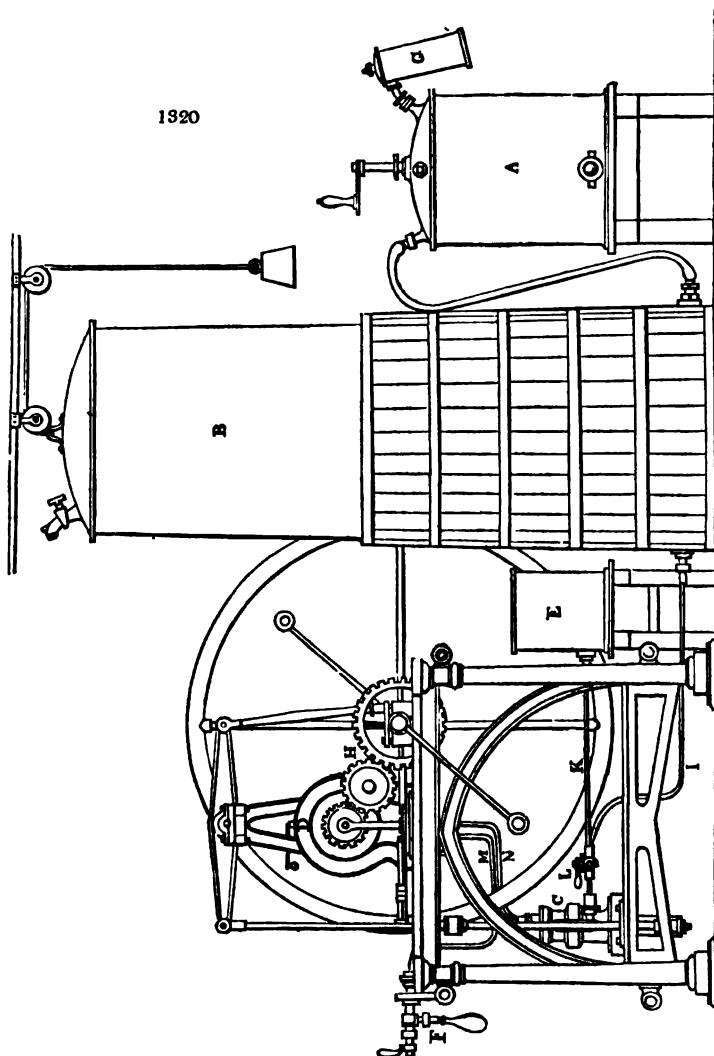
IMPROVED SODA-WATER APPARATUS, AS MADE BY MR. HAYWARD TYLER,
OF MILTON STREET.

Fig. 1318. front view of the soda-water machine. Fig. 1319. end view of the same.

empying the water out of the tub, *l*, union joint, to which is fixed a copper pipe, passing through the water in the tub, to deliver the gas as generated into the copper gasometer. *m*, another union joint, with a similar copper pipe, passing through the water in the tub, and projecting two or three inches above the surface of the water, to convey the gas from the copper gasometer to the soda-water bottle, and another similar pipe for the soda-water bottle. *n*, bottling nipple. *o*, valve-piece. *p*, piston of the pump. *q*, copper pan for holding the solution of soda. *r*, copper pipe for conducting the solution of soda to the force pump. *s*, *s*, two cocks for regulating the admission of the solution and gas to the pump. *t*, copper pipe through which the soda-water is forced to the condenser. *u*, piston wheel, to give motion to the agitator revolving inside the condenser. *v*, *v*, wheel for driving ditto. *w*, *w*, cast-iron frame for carrying machinery. *x*, *x*, cast-iron fly-wheel. *y*, *y*, wrought-iron crank. *z*, *z*, *z*, wood stools and curb, upon which the whole of the machinery is fixed.

a, lead generator, for making the gas. *b*, lead pot, for holding sulphuric acid. *c*, handle for moving the agitator of the receiver, which stirs up the ingredients in the lead generator. *d*, cap and screw, for charging the lead pot with sulphuric acid. *e*, swivel-joint, which is movable, for occasionally throwing in portions of sulphuric acid for generating gas. *f*, stuffing-box for agitator with packing and screw, for charging the water with sulphuric acid and water. *g*, cap and screw, for emptying contents of ditto. *h*, iron pipe to convey the gas from the lead generator to work in. *i*, copper gasometer. *j*, strong iron frame, for gasometer and tub to stand on, firmly fixed together by three wrought-iron rods, *j*, *j*, *g*, *g*, two pulleys, for carrying rope and counterbalance weight *k*, for balancing copper gasometer. *l*, cock for discharging atmospheric air contained in the gasometer before making the gas. *k*, cock for occasionally





SODIUM, the metallic basis of soda, is obtained by processes similar to those by which potassium is procured. By fusing hydrate of soda with a little hydrate of potassa, a mixture is obtained, which yields more readily than soda by itself to the decomposing action of iron-turnings at a high heat, in a bent gun-barrel. The portion of potassium produced may be got rid of, by digesting the alloy for a few days in some naphtha or oil of turpentine contained in an open vessel. The sodium remains at the bottom of the liquid. Pure sodium may, however, be prepared at once, by subjecting incinerated tartrate of soda to heat in the apparatus of Brunner, described under **POTASSIUM**. It is white, like silver; softer and more malleable than any other metal, and may be readily reduced into very thin leaves. It preserves its malleability till it approaches the melting point. Its specific gravity is 0.970. It softens at the temperature of 122° F., and at 200° it is perfectly fluid: but it will not rise in vapour until heated to nearly the melting point of glass. In the air it oxidizes slowly, and gets covered with a crust of soda; but it does not take fire till it is made nearly red-hot; and then it emits brilliant scintillations. When thrown upon water, it is rapidly oxidized, but without kindling, like potassium. If a drop of water be thrown upon it, it

becomes so hot by the chemical action as to take fire. There are three oxides of sodium; 1. the suboxide; 2. the oxide, or the basis of common soda; and, 3. the suroxide; the last being formed when sodium is heated to redness upon a plate of silver.

SOILS, ANALYSIS OF. Having been some time ago engaged in a minute chemical examination of the soil of a large farm, remarkable for perennial fertility without manure*, I have been led to adopt some simplified methods of analysis, which may to a certain extent be practised by ordinary farmers, and may throw some light on the means of improving permanently the composition of their lands. The field from which the sample subject of analysis was taken, is situated on Marsh Farm, in Haveling Level, in the parish of Hornchurch, Essex, not far from the banks of the Thames, and nearly opposite to Erith. R. M. Kerrison, Esq., M. D., F. R. S., the proprietor, informs me that no manure has ever been applied to this farm of 200 acres during a period of at least fifty years, except once; and in that season the wheat became so heavy as to be in a great measure spoiled. It produces every variety of crop most abundantly.

The substratum, which lies beneath a three-foot bed of the soil, is an alluvial deposit, replete with decaying vegetable matter; the remains probably of some ancient forest, which existed prior to the formation of the Daggenham Breach, through which the river had inundated a large district of country, and kept it submerged till about two centuries ago; when it was stopped out by the aid of a parliamentary grant, administered under the direction of a skilful engineer. The soil over the whole farm is of very uniform texture and appearance; being a finely comminuted friable loam, quite free

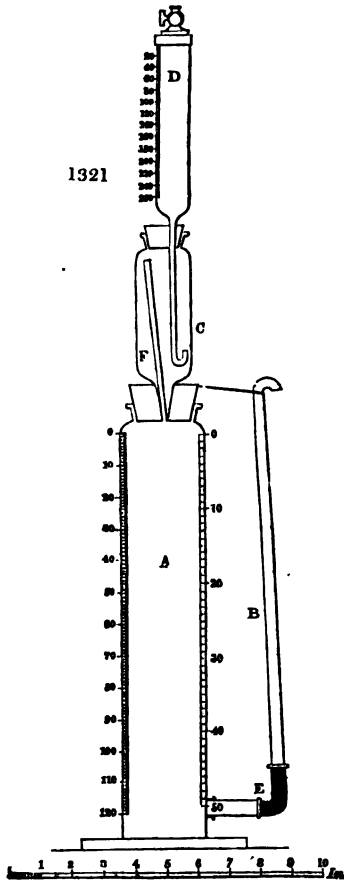
from stones, consisting of a fortunate mixture of fine siliceous sand, clay, oxide of iron, and carbonate of lime, with minute proportions of phosphate of lime and magnesia, but very little organic matter. It would seem, therefore, to derive its principles of fertility chiefly from the atmosphere, and the emanations from the subsoil.

The specific gravity of the soil, in its average state of dryness, is 2.2 to water called 1.0; indicating the presence of but little vegetable matter.

100 parts of it collected after a period of ordinary dry weather lose 11.2 by a steam heat of 212°, and readily re-absorb that portion of moisture when again exposed to damp air. When the dried residuum is calcined at a dull red heat, six parts of vegetable substance are burned away; at a higher temperature the carbonate of lime would become calcined, and cause an additional loss of weight, which might inconsiderately be mistaken for organic matter.

The first problem in an agricultural analysis, is to find the proportion of calcareous matter, as carbonate and phosphate of lime. This may be easily solved with the aid of the following instrument (*fig. 1321.*), which may be called the *Limestone Meter*, one of which was presented and explained by me to the Council of the Royal Society of Agriculture on the 29th of May, 1848.

A, is a cylinder of glass, two inches in diameter, and fourteen inches long, graduated on one side with a scale, into spaces of 100 water-grain measures from 0 to 12,000, marked 10, 20, 30, &c.; and graduated on the other side into spaces of 240 water-grain measures, each. The former scale is used for the analysis of all sorts of alkaline carbonates, and also of acids; the latter is adapted to the direct analysis of carbonate of lime and marls; and indirectly to that of phosphate of lime and carbonate of magnesia.



* All the stable-yard dung is sold by the farmer.

The cylinder *A*, has a tubulure in its side near the bottom; this is closed with a cork, in the axis of which a short glass tube is cemented, hooped externally to a collar of caoutchouc *x*, which serves as a joint to the upright long glass tube *a*, held near its upper recurved end in a hooked wire.

The top of the cylinder *A* is closed with an elastic cork, through a perforation in which the taper tail of the little phial *c* passes air-tight. The small tube *r*, open at both its ends, is cemented on its outer surface, into the bottom of the phial *c*, so as to close it, while the tube itself opens a free passage to gas, from the shoulder of the phial down into the cylinder *A*.

The mouth of the phial *c* is shut with a cork, through which the small end of the tube *b* passes air-tight. The tube *b* is graduated into spaces of 10, 20, &c. water-grain measures up to 250, and is closed at top with a stopcock. Its lower and capillary extremity is recurved.

In ascertaining with this instrument the proportion of real carbonate of lime, in any limestone, marl, or soil, proceed as follows:—

Lift out the phial *c*, and pour water into the cylinder *A* till it stands about half an inch below the line marked *O*, and fill up this space with common linseed-oil. Restore the phial *c* to its place, pressing it in air-tight. Then take out its cork with its graduated tube, and introduce into the phial as many grains weight of the soil or marl as it is proper to operate upon. Of an average limestone 50 grains are sufficient, because the magnified scale of the *lime-proof* is adapted to the analysis of 50 grains of pure carbonate of lime. Of soils and marls, 100, 200, or even 500 grains, may be taken, because these substances will rarely contain one-tenth their weight of carbonate of lime. But as the result may always be obtained within five minutes, at the cost of half a farthing, several successive experiments may be made on different weights of the sample. Having introduced the proper weight of the object into the phial, cover it with water, till this stands a little above the point to which the recurved tube descends. Holding *b* in the hand, dip its bent point into a phial containing ordinary muriatic (hydrochloric) acid, diluted with its own bulk of water, and applying the mouth to the opened stop-cock, suck up the acid into the tube till this be about two-thirds full, then turn the key of the cock before it is taken from the lips, and the acid will not drop out when the tube is held upright. Replace the cork with its tube *b* in the phial *c*. Detach the long tube, *a*, from its wire-rest with the left hand, and hold its curved extremity above an empty basin; then with the right hand open the stop-cock of *b*, to let a little acid run down upon the marl, but shut it almost instantly again, lest too much acid should escape, and cause so brisk an effervescence as to occasion an overflow of the mixture into the small tube *r*. The disengaged carbonic acid escapes through the tube *x*, presses on the surface of the oil in *A*, and causes a stream of water to flow from the tube *a*, into the subjacent basin. When the water ceases to run, open the stop-cock again, when more acid will descend, cause a fresh extraction of gas, and a further flow of water. The curved end of the tube *a* should be progressively lowered, as the oil falls in *A*, so as to maintain its level and that in the tube, in the same horizontal plane. Whenever gas ceases to be extricated by the muriatic acid, the experiment is completed, and the number on the *lime-meter* scale opposite to the upper surface of the oil, denotes the number of grains of carbonate of lime, in the quantity of limestone, marl, or soil, put into the phial *c* for experiment. A little carbonic acid gas remains condensed in the muriatic solution, but this is not more than equivalent to the bulk of liquid acid introduced into the capacity of the apparatus; so that no compensation need be made on this account. For the purpose of minute chemical research, that portion of gas may be expelled by surrounding the phial *c* with a cloth wrung out of hot water, and the volume of dilute acid added may also be taken into the account. Thus the composition of carbonates by an acid, and of acids by a bi-carbonate, may be determined by means of this instrument with equal rapidity and precision.

The contents of the phial may be poured out into a porcelain capsule, gently heated, and thrown on a filter. The lime of the carbonate, as well as the phosphate of lime and the magnesia, will pass through in solution along with a very little iron. On saturating the acidulous liquor with water of pure ammonia, phosphate of lime (if present) will fall, and may be drained on a filter and dried. Taken off the dried filter, and digested with a little dilute sulphuric acid, sulphate of lime will result, characterized by its entire insolubility in dilute alcohol. Hence the sulphate washed with vinous spirits, dried and calcined, will represent by its weight one-fifth more than the original weight of the phosphate. By the action of the sulphuric acid, the iron precipitated by the ammonia with the phosphate is got rid of.

The magnesia, unless its proportion has been very great, will all remain dissolved as ammonia-muriate, and its quantity may be ascertained by precipitating it either with soda, or phosphate of soda. In the former case, the substance obtained, when washed on a filter, dried and ignited, is pure magnesia; in the latter, it is the ammonia-

phosphate of magnesia; and when dried at the moderate heat of 120° Fahr., it represents by its weight about six times that of the magnesia present; or for 100 parts, $16\frac{1}{2}$ of magnesia.

When a complete analysis of a soil is to be made, the following apparatus is convenient:—

A large glass flask, or matrass, with a sucked-in or concave thin bottom. This should hold at least a quart of water; and when the soil and dilute acid are introduced, it is to be placed on a stand over the gentle flame of a spirit lamp, while the beak of a large glass funnel, having its mouth covered with a porcelain basin, filled with cold water, is inserted into the neck of the flask. By this arrangement a continual ebullition may be maintained in the mixture of soil and acid, without loss of acid, or nuisance from its fumes, because the vapours are condensed whenever they reach the cold basin above the funnel, and a perpetual cohobation takes place. A boiling heat may be kept up in this way till every constituent of the soil, except the silica, becomes dissolved. Muriatic acid is generally preferred for the analysis of soils, and in somewhat greater quantity than the bases in the given weight of soil can neutralise. The funnel and porcelain basin should be properly supported upon the rings of a chemical stand. I generally subject 100 grains of soil to the action of boiling dilute acid in this way for 6 or 8 hours; at the end of that period I throw the contents of the matrass upon a filter, and supersaturate the filtered liquid with ammonia. The silica which remains on the filter having been washed in the process, is dried, ignited, and weighed.

The alumina, iron-oxide, and phosphate of lime, thrown down by the ammonia, being washed in the filter, and dried to a cheesy consistence, are removed with a bone or tortoise shell blade into a silver basin, and digested with heat in a solution of pure potash, whereby the alumina is dissolved, when its alkaline solution is to be passed through a filter, then saturated with muriatic acid, and next supersaturated with ammonia. Pure white alumina falls, which is to be separated on a filter, washed, dried, ignited, and weighed.

The iron and phosphate of lime on the alkaline filter may be dried, gently ignited, and weighed, or otherwise directly separated from each other without that step, by the action of dilute alcohol, acidulated with sulphuric acid, at a gentle heat. Thus the iron oxide will be dissolved, and its solution may be passed through a filter, while the sulphate of lime will remain upon it, to be dried, ignited, and weighed. Five parts of it correspond to four of phosphate. The iron is obtained by precipitation with water of ammonia, filtration, and ignition.—*For phosphoric acid, see the sequel.*

The first filtered liquor, with excess of ammonia, contains the lime of the carbonate, and the magnesia. The former is separated by a solution of oxalate of ammonia, with digestion in a moderate warmth for a few hours, filtration, and very gentle ignition of the washed dry powder, when the pure carbonate of lime is obtained. The magnesia, existing in the filtered liquor as an ammonia-muriate, may be obtained by precipitation with soda, or phosphate of soda, as already described.

For some refractory soils, in which the alumina exists as a double or triple silicate, it becomes necessary to fuse 50 grains of the sample, in fine powder, mixed with four times its weight of dry carbonate of soda, the mixture being put into a platinum crucible, and into a cavity in its centre, 50 grains of hydrate of potash being laid.

The crucible being slowly raised to a red-white heat, affords a fused liquid quite homogeneous, of a grey or brown colour, according to the metals present in it. Manganese gives a purple tint; and iron a reddish brown. The fused matter should be poured out into a shallow platinum basin; and, whenever it cools, it should be pulverised, dissolved in dilute muriatic acid, the solution evaporated to dryness, the dry mass again digested in hot water, acidulated with muriatic acid, and the whole thrown upon a filter. Pure silica will remain on the filter, to be washed, dried, ignited, and weighed.

The filtered liquor contains the remaining constituents of the soil, and is to be treated as already described.

Besides these systematic investigations, researches may be made for certain peculiar substances, and especially the neutro-saline constituents. In this view 100 grains of the soil may be triturated with 20 times their weight of distilled water, placed in a beaker, till the clayey matter subsides, and the clear portion may then be decanted into a filter. A little of the filtered liquor should be tested with nitrate of barytes, and also with oxalate of ammonia; and if each portion yields a precipitate, they show the presence of sulphate of lime; and the following steps ought to be taken to eliminate it entirely; 200 grains of the soil should be triturated with a quart of distilled water, holding 50 grains of sal-ammoniac in solution. The mixture should be allowed to clarify itself by subsidence, when the supernatant clear liquor is to be filtered, and evaporated down to 2 ounce measures, and then mixed with that bulk of strong

whiskey (11 per cent. overproof). The whole sulphate of lime will be now separated from the fluid, and after being drained on a filter, may be dried, ignited, and weighed.

For determining the alkaline salts, the water filtered from the 100 grains of the soil should be evaporated down to one-fifth of its bulk, and then treated — 1st, with nitrate of barytes, for the sulphates; 2d, with nitrate of silver for the muriates; 3d, with oxalate of ammonia, for the nitrate or muriate of lime (provided no sulphate of lime is indicated by the first test); 4th, with litmus paper, for alkaline or acid reaction; 5th, with soda-chloride of platinum for potash salts, which are very valuable for the growth of many plants.

The portion of soil tested for potash salts should, before being digested in water, be gently calcined, to ensure the expulsion of every particle of ammoniacal salt, otherwise the precipitate afforded by soda-chloride of platinum would be fallacious.

Another peculiar research of great importance is that which determines the amount of ammonia in a soil; and which may exist either ready formed, or in its elements, capable of affording a portion of the azotic food so indispensable to vigorous vegetation. The actual ammonia is easily obtained by distilling the soil along with some milk of lime. The distilled water will contain all the volatile alkali, which may be measured by the number of drops of a standard dilute acid which it will saturate.

The potential ammonia, slumbering, so to speak, in its embryo elements, may be estimated by igniting 200 grains of the soil with its own weight of a mixture of hydrate of soda and quicklime, as described in my memoir on "Guano," in this work.

I have subjected the soil of Dr. Kerrison's farm to the various modes of research above enumerated, and have obtained the following results:—

1. By the application of my *limestone-meter* I obtained carbonic acid gas, equivalent to 9 grains of carbonate of lime.

2. By igniting 200 grains of the soil along with 200 grains of mixed quicklime and hydrate of soda, in the appropriate apparatus, I obtained 0·34 grains of ammonia, or 0·17 per cent. of the weight of the soil. Hence, 600 grains of the soil contain the azotic equivalent of one grain of ammonia. This remarkable fact reveals most plainly one secret source of the uninterrupted production of rich crops of cereals and other plants from it, without receiving any manure. How appropriate to such land is Virgil's beautiful title of the subject of his "*Georgics*," *justissima tellus!*

3. By the process of cohabitation for 8 hours, with dilute muriatic acid, as also by the process of fusion with alkalis in a platinum crucible, and the subsequent treatment above detailed, I obtained—

| | | | | | |
|--|---|---|---|---|------|
| 1. Silica | - | - | - | - | 56·0 |
| 2. Alumina | - | - | - | - | 8·0 |
| 3. Oxide of iron | - | - | - | - | 5·5 |
| 4. Carbonate of lime | - | - | - | - | 9·0 |
| 5. Sub-phosphate of lime | - | - | - | - | 0·4 |
| 6. Magnesia (carbonate) | - | - | - | - | 0·5 |
| 7. Moisture separable by steam-heat | - | - | - | - | 11·3 |
| 8. Organic matter, chiefly vegetable mould | - | - | - | - | 6·6 |
| 9. Moisture separable at a red-heat | - | - | - | - | 2·7 |

100·0

besides traces of muriate of soda, and muriate of lime (chlorides of sodium and calcium). The iron exists mostly in the state of protoxide, a circumstance owing, probably, to exhalations from the subsoil of sulphuretted, phosphuretted, and carburetted hydrogen. The fresh soil is of a grey colour, but becomes ochrey-red by calcination.

100 grains of the said soil, dried at 212°, absorb 8 grains of moisture in 24 hours; while 100 grains of the comparatively sterile soil of Regent's Park, dried equally, absorb only 5 grains: a difference due chiefly to the finer comminution of the former.

Since the phosphates are such precious ingredients towards fertilizing soils, it is desirable to possess a clear and simple test of their presence. For this purpose digest the soil, for an hour or so, with a moderate heat, in dilute nitric acid, free from muriatic (viz, which affords, when largely diluted, no precipitate, by the addition of a solution of nitrate of silver). Throw the mixture on a filter, and to the filtered liquid add potash-water, cautiously, till the instant that a precipitate begins to appear; then drop into it a weak solution of nitrate of silver. If any phosphoric salts be present, a yellowish precipitate will immediately fall, which is re-soluble in an excess of nitric acid. Whatever is not thus dissolved is chloride of silver, and ought to be separated by filtration. On adding then weak water of potash (not ammonia) cautiously

to the filtered liquid, the pure phosphate of silver will be obtained, without any alumina or iron, provided the liquid be still acidulous in a slight degree. It ought to be remembered that chloride of silver falls in a *white curdy* form, quite different from that of the phosphate of silver. The portion of soil used for this experiment should be fresh and not calcined, because the *phosphates*, when ignited, afford white precipitates with salts of silver. The stronger the solution of the phosphoric saline compound is, the more characteristic is the yellow precipitate with silver; and then ammonia may be used for effecting the partial saturation of the acid excess. Sulphate of magnesia is an excellent re-agent for detecting phosphoric acid, and for separating it from the above acid solution, when it is partially neutralised with ammonia; for the magnesia forms, with the phosphoric acid and ammonia, the insoluble granular precipitate of ammonia-magnesian phosphate. A solution of sulphate of magnesia, containing a little sal-ammoniac, is probably the best test-liquor for detecting phosphates in faintly acidulous, but still better in neutral solutions.

In almost all soils of an arable nature under cultivation in this country, there is a sufficiency of calcareous matter present to counteract the combination of phosphoric acid with alumina or oxide of iron, for which reason it would be an idle refinement of agricultural analysis to search for phosphates of alumina and iron. As for manganese, often associated with iron, it exists in too small a proportion, and is possessed of too little value, to make it worth while to effect its separation. It gives to calcined iron-oxide a black hue, and is characterised in its saline solutions by the flesh-coloured precipitate which it affords with hydro-sulphuret of ammonia, after the whole of the iron has been thrown down by boiling the solution of the two metals with pure carbonate of lime.

The organic matter in any soil may be correctly estimated by calcining its powder pretty strongly till the carbonic acid be expelled from the lime in it. The loss of weight, deducting that due to the carbonic acid gas (which is known from an independent experiment), gives the quantity of organic matter. Its quality is determined by the ultimate analysis by means of hydrate of soda and quicklime, as previously stated.

The phosphoric acid may be also estimated by digesting the ignited soil in nitric acid, precipitating the filtered solution with acetate of lead in excess. If phosphoric acid be present it will produce phosphate of lead, mixed with a sulphate, if any sulphuric acid existed in the soil. Wash, ignite, and weigh the precipitate. Digest in nitric acid, decompose the solution with sulphuric acid, add alcohol, throw the mixture upon a filter, and weigh the sulphate of lead remaining left upon it. From this weight, that of the oxide of lead becomes known; since 152 of sulphate of lead contain 112 of oxide. The quantity of sulphuric acid found by nitrate of barytes in another equal portion of the soil, being added to the oxide of lead just determined, will constitute a sum, which, being subtracted from the weight of the acetate of lead precipitate, will represent the amount of phosphoric acid in the soil.

In the very elaborate analyses of the ashes of different kinds of wheat, by Fresenius and Will in Germany, Biehon in Holland, Boussingault in France, and others, one half of the whole was found to be phosphoric acid.

In the preceding method of analysis the detection of potash is made directly by means of the soda-chloride of platinum. The following process is adapted to determine the quantity of that important alkali, as well as of soda. The solution of the soil in hydrochloric acid is to be treated with barytes water till the liquid blues reddened litmus paper; it is then heated and thrown upon a filter. By this means the whole of the sulphuric and phosphoric acids, as also of the oxide of iron, the magnesia, and the lime that was combined with the phosphoric acid, is separated. The precipitate is to be washed till the water which passes ceases to be affected by nitrate of silver. To the clear liquor, gently heated, carbonate of ammonia mixed with caustic ammonia is to be added, to throw down all the barytes. The whole is to be left in repose for a little till a granular precipitate falls, and it is then to be thrown upon a filter and washed. The filtered liquor being evaporated to dryness, the residuum is to be ignited in a platinum or silver capsule, to expel all the ammonia, when it can contain only the alkaline metals, potassium and sodium, in the state of chlorides. After being weighed, it is to be dissolved in a very little water, when a trace of magnesia may appear (which can be eliminated and weighed); and the amount of potash is to be estimated from the weight of the precipitate produced by soda-chloride of platinum. The difference of the weight of the whole chloride and of that corresponding to the potash just found gives the quantity of sodium-chloride, and of course of soda, in the soil.

SOLDERING (*Souder*, Fr.; *Löthen*, Germ.); is the process of uniting the surfaces of metals, by the intervention of a more fusible metal, which being melted upon each surface, serves, partly by chemical attraction, and partly by cohesive force, to bind them

together. The metals thus united may be either the same or dissimilar; but the united metal must always have an affinity for both. Solders must be, therefore, selected in reference to their appropriate metals. Thus tin-plates are soldered with an alloy consisting of from 1 to 2 parts of tin, with 1 of lead; pewter is soldered with a more fusible alloy, containing a certain proportion of bismuth added to the lead and tin; iron, copper, and brass are soldered with spelter, an alloy of zinc and copper, in nearly equal parts; silver, sometimes with pure tin, but generally with silver-solder, an alloy consisting of 5 parts of silver, 6 of brass, and 2 of zinc; zinc and lead, with an alloy of from 1 to 2 parts of lead with 1 of tin; platinum, with fine gold; gold, with an alloy of silver and gold, or of copper and gold; &c.

In all soldering processes, the following conditions must be observed: 1. the surfaces to be united must be entirely free from oxide, bright, smooth, and level; 2. the contact of the air must be excluded during the soldering, because it is apt to oxidize one or other of the surfaces, and thus to prevent the formation of an alloy at the points of union. This exclusion of air is effected in various ways. The locksmith encases in loam the objects of iron, or brass, that he wishes to subject to a soldering heat; the silversmith and brazier mix their respective solders with moistened borax powder; the coppersmith and tinman apply sal ammoniac, rosin, or both, to the cleaned metallic surfaces, before using the soldering-iron to fuse them together with the tin alloy. The strong solder of the coppersmith consists of 8 parts of brass and 1 of zinc; the latter being to add to the former, previously brought into a state of fusion. The crucible must be immediately covered up for two minutes till the combination be completed. The melted alloy is to be then poured out upon a bundle of twigs held over a tub of water, into which it falls in granulations. An alloy of 3 parts of copper and 1 of zinc forms a still stronger solder for the coppersmiths. When several parts are to be soldered successively upon the same piece, the more fusible alloys, containing more zinc, should be used first. A softer solder for coppersmiths is made with 6 parts of brass, 1 of tin, and 1 of zinc; the tin being first added to the melted brass, then the zinc; and the whole well incorporated by stirring.

The edges of sheet lead for sulphuric acid chambers, and its concentration pans, are joined together by melted lead itself, because any solder containing tin would soon be corroded. With this view, the two edges being placed in contact, are flattened down into a long wooden groove, and secured in their situation by a few brass pins driven into the wood. The surfaces are next brightened with a triangular scraper, rubbed over with candle grease, and then covered with a stream of hot melted lead. The riband of lead thus applied is finally equalized by being brought into partial fusion with the plumber's conical iron heated to redness; the contact of air being prevented by sprinkling rosin over the surface. The sheets of lead are thus *burned* together, in the language of the workmen.

SOLDERING OF LEAD, and other metals, is called by its inventor, M. de Riche-mont, *autogenous*, because it takes place by the fusion of the two edges of the metals themselves, without interposing another metallic alloy, as a bond of union. He effects this purpose, by directing a jet of burning hydrogen gas, from a small movable beak, upon the two surfaces or edges to be soldered together. Metals thus joined are much less apt to crack asunder at the line of union, by differences of temperature, flexure, &c., than when the common soldering processes are employed. The fusing together the edges of lead sheets, for making sulphuric acid chambers, has been long practised in this country, but it was performed by pouring some of the melted metal along the line of junction, and afterwards removing its excess by means of a plumber's soldering iron. The method of M. Riche-mont is a great improvement upon that old practice. It is much quicker and more convenient.

SOOT (*Noir de fumée, Suie, Fr.*; *Rus, Flatterrus, Germ.*); is the pulverulent charcoal condensed from the smoke of wood or coal fuel. A watery infusion of the former is said to be antiseptic, probably from its containing some creosote.

The soot of pitcoal has not been analyzed with any minuteness. It contains some sulphate and carbonate of ammonia, along with bituminous matter.

SORBIC ACID, is the same with malic acid; which see.

SOY, is a liquid condiment, or sauce, imported chiefly from China. It is prepared with a species of white haricots, wheat flour, common salt, and water; in the proportions respectively of 50, 60, 50, and 250 pounds. The haricots are washed, and boiled in water till they become so soft as to yield to the fingers. They are then laid in a flat dish to cool, and kneaded along with the flour, a little of the hot water of the decoction being added from time to time. This dough is next spread an inch or an inch and a half thick upon the flat vessels (made of thin staves of bamboo), and when it becomes hot and mouldy, in two or three days, the cover is raised upon bits of stick, to give free access of air. If a rancid odour is exhaled, and the mass grows green, the process goes on well; but if it grows black, it must be more freely exposed to the air. As soon as all

the surface is covered with green mouldiness, which usually happens in eight or ten days, the cover is removed, and the matter is placed in the sunshine for several days. When it has become as hard as a stone, it is cut into small fragments, thrown into an earthen vessel, and covered with the 250 pounds of water having the salt dissolved in it. The whole is stirred together, and the height at which the water stands is noted. The vessel being placed in the sun, its contents are stirred up every morning and evening; and a cover is applied at night, to keep it warm and exclude rain. The more powerful the sun, the sooner the soy will be completed; but it generally requires two or three of the hottest summer months. As the mass diminishes by evaporation, well water is added; and the digestion is continued till the salt water has dissolved the whole of the flour and the haricots; after which the vessel is left in the sun for a few days, as the good quality of the soy depends on the completeness of the solution, which is promoted by regular stirring. When it has at length assumed an oily appearance, it is poured into bags, and strained. The clear black liquid is the soy, ready for use. It is not boiled, but it is put up into bottles, which must be carefully corked. Genuine soy was made in this way at Canton, by Michael de Grubbens. See *Memoirs of Academy of Sciences of Stockholm* for 1803.

SPARRY IRON ORE. The sparry iron ore is used for the manufacture of pig iron, and changes in roasting into magnetic ironstone, discernible by the crystals. The manufacture of iron into bars, by means of gas, is but in its infancy; but the iron produced in this manner is considered to be preferable to that produced by means of charcoal, and to the puddled iron in bars made by pitcoal.

The lignites of Germany have not been found favourable to the production of good iron; the principle has therefore been introduced, of distilling the fuel in close vessels, and using the resulting gases, in a state of combustion in the furnace, as the source of heat to weld iron. The results, as far as the experiment has yet been tried, are satisfactory, and the use of gases is rapidly extending in the iron districts of the Continent. The relative value of the iron-producing states of Europe may be inferred from the following return, obtained in 1845:—

| | | | | | |
|-------------------------------|---|---|---|---|-----------|
| Great Britain | - | - | - | - | 2,000,000 |
| United States | - | - | - | - | 502,000 |
| France | - | - | - | - | 448,000 |
| Russia | - | - | - | - | 400,000 |
| Prussian Zollverein | - | - | - | - | 300,000 |
| Austria | - | - | - | - | 190,000 |
| Belgium | - | - | - | - | 150,000 |
| Sweden | - | - | - | - | 145,000 |
| All the other European States | - | - | - | - | 76,000 |

SPECIFIC GRAVITY, designates the relative weights of different bodies under the same bulk; thus a cubic foot of water weighs 1000 ounces of avoirdupois; a cubic foot of coal, 1350; a cubic foot of cast iron, 7280; a cubic foot of silver, 10,400; and a cubic foot of pure gold, 19,200: numbers which represent the specific gravities of the respective substances, compared to water=1000. See **ALLOY**.

SPECULUM METAL, is an alloy of copper and tin; described under **COPPER**.

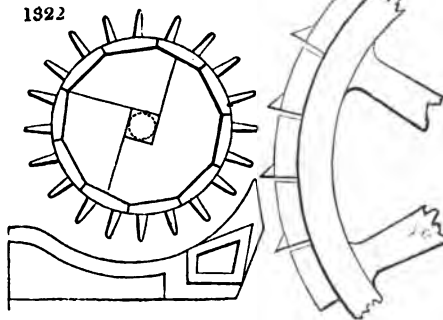
SPERMACETI, the *Cetine* of Chevreul. In certain species of the *cachalot* whale, as the *Physeter macrocephalus*, *turnio*, *microps*, and *orthodon*, as also the *Delphinus edentulus*, the fat of some parts of their bodies contains a peculiar kind of stearine, called spermaceti. The oil obtained from cavities in the bones of the cranium of the above cetaceæ is the richest in this kind of stearine. This being thrown into great filter-bags, the spermaceti oil passes through, and is subsequently purified by the addition of a small quantity of potash lye, which precipitates certain matters by neutralizing the acid that held them in solution. The solid which remains on the filter is next squeezed in bags, by means of a horizontal hydraulic press encased in steam, then digested with a weak potash lye, in order to dissolve out any oil which may continue to adhere to it, washed with water, finally dissolved in a tub by the agency of steam, laden into tin pans, and allowed slowly to concrete into a white semi-transparent brittle lamellar crystalline mass, which forms elegant candles.

At 60° its specific gravity is 0.943. It melts at 112.5°; 100 parts of alcohol at 0.821 dissolve 3½ of it, of which 0.9 are deposited on cooling. Warm ether dissolves it in very large quantities. It is soluble also in the fat of volatile oils; and if the solutions have been saturated while hot, the greater part of the spermaceti crystallizes on cooling. When this substance has been purified by digesting alcohol upon it repeatedly, what remains is the *cetine* of Chevreul, or pure spermaceti. Its melting point has now become 116° F., and its boiling point 616° F., at which it distils without alteration. Caustic alkaline lyes saponify it with difficulty.

SPINNING. The greatest improvement hitherto made in forming textile fabrics, since the era of Arkwright, is due to Mr. G. Bodmer, of Manchester. By his patent

inventions the several organs of a spinning factory are united in one self-acting and self-supplying body—a system most truly *automatic*. His most comprehensive patent was obtained in 1824, and was prolonged by the Judicial Committee of the Privy Council, for 7 years after the period of 14 years was expired. It contained the first development of a plan by which fibres of cotton, flax, &c. were lapped and unlapped through all the operations of cleaning and blowing, carding, drawing, roving, and spinning; in the latter, however, only as far as the operation of feeding is concerned. The lapping from the blower was then not new, but the lapping directly and in connection with the carding engines was his invention, and was brought by him into operation at St. Blaise in the Black Forest, several years before he took out his patent in England. The method applied through all the following operations was then new. Mr Dyer's and several other patents granted subsequently were decided and acknowledged infringements. The patent of 1824 was the beginning; the result of which was the several patents for improvements in 1835, 1837, 1838, and 1842, of Mr. Bodmer.

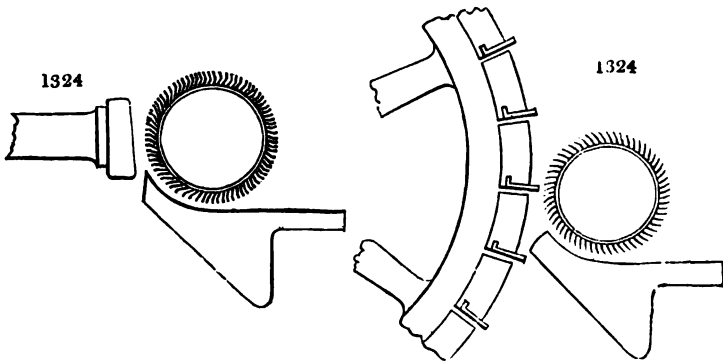
By a machine generally called a Devil or Opener ("Wolf," in German), which consists of a feeding-plate set with teeth and a roller covered with spikes (see *fig 1322.*),



Patent of 1835.

the cotton is cleared from its heaviest dirt and opened. This machine delivers the cotton into a room or on to a travelling cloth, from which it is taken, weighed in certain portions, and spread upon cloth in equal portions; this is then rolled up, and placed behind the first blower.

The first blower has a feeding-plate like *fig. 1323.*, without teeth, and over this plate the cotton is delivered to the operation of the common beaters, from which it is received



Patent of 1835.

Patents of 1824 and 1835.

into a narrow compartment of $4\frac{1}{2}$ or 5 inches broad, and wound, by means of his lap-machines upon rollers in beautifully level and well-cleaned laps. Eight of these narrow laps are then placed behind a second blower, of a similar construction to the one of *fig. 1324.* Instead of the common beater, however, a drum with toothed straight edges is well; but *fig. 1324.*), which opens the cotton still more, and separates the fibres from one

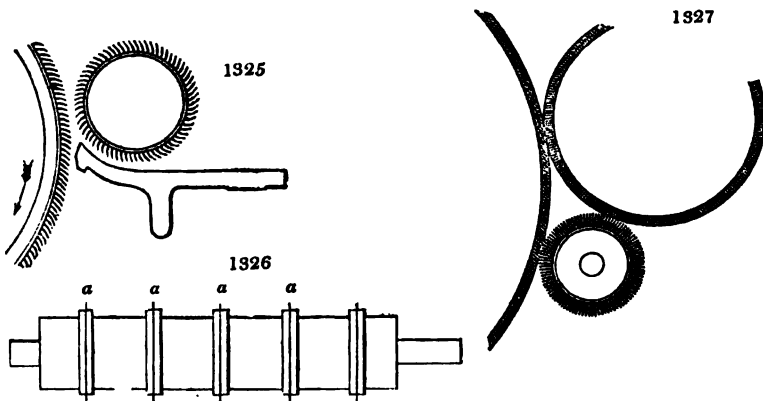
another. The cotton is again formed into similar narrow laps, which are still more equal than the preceding ones, and eight of these laps are then placed behind the carding engine. It was only by applying his lap-machine, patented in 1842, that he succeeded in forming small laps on the blower; without this he could not perform the doffing of the laps without stopping the wire-cloth, and in doing this, an irregular lap would be formed because of the accumulating of the falling cotton in one place while the wire-cloth was standing.

Carding Engine. — The patent of 1824 showed a mode of coupling a number of carding engines, the product of which was delivered upon an endless belt or a trough, and at the end of this trough was wound upon a roller. This arrangement wants no description, as it is generally known. I have seen it in use on the Continent.

When a set of cards work together, any interruption or stoppage of a single carding engine causes a defect in the produce of the whole lap. Interruptions occurred several times a day by the stripping of the main cylinder, and during this operation the missing band or sliver was supplied out of a can, being the produce of a single carding engine working into cans (a spare card). The more objectionable defect was, however, the difference of the product of the carding engine after the main cylinder had been stripped; the band or sliver from it will be thin and light until the cards of the main cylinder are again sufficiently filled with cotton, when the band will again assume its proper thickness. Another irregularity was caused by the stripping of the flats or top cards, but was not so fatal as the first one. These defects were of course a serious drawback in his system of working, the latter of which he provided against in his first patent by stripping the top cards by mechanism; the former, however, was only conquered by his invention of the self-strippers for the main cylinders; thus the carding engine may now work from Monday morning till Saturday night without interruption, the cylinders requiring only to be brushed out every evening; the consequence is, that much time is gained, and a very equal, clean, and clear product is obtained. Old carding engines to which he applied his feeders (see *fig. 1325*.) and main cylinder-clearers produce much superior work, and increase the production from 18 to 24 per cent.

The main cylinder-clearer consists of a very light cast iron cylinder, upon which five, six, or more sets of wire brushes are fixed, which are caused to travel to and fro across the main cylinder; the surface or periphery of the brushes overrunning the surface or periphery of the main cylinder by 8 or 10 per cent., the brushes thus lifting the cotton out of the teeth of the cards of the main cylinder, and causing the dirt and lumps to fall.

As the brushes are not above a quarter-inch in breadth and travel to and fro, it is clear that no irregularity can take place in the fleece which comes from the doffer; not more than 1/40th part of the breadth of the cylinder being acted upon at the same time. *Figs. 1326, 1327.* give an idea of the clearer: the mechanism within the clearer



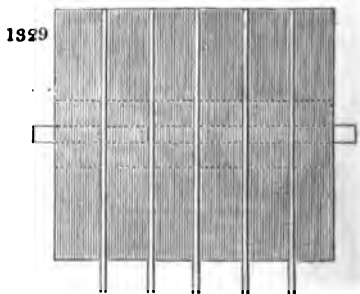
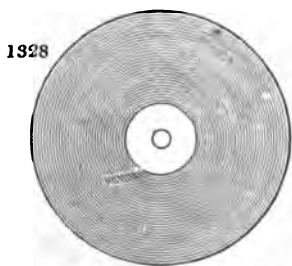
Patents of 1838 and 1842.

and by which the brushes, *a*, are caused to travel is simple and solid. The main cylinders for the carding engines are made of cast iron, the two sets of arms and rims are cast in the same piece; when complete they weigh 50 lbs. less than those made of wood.

The new lap machine connected with these engines is almost self-acting; a girl has only to turn a crank when the lap is full; by this turn the full lap is removed and an empty roller put in its place, the band of cotton is cut, and no waste is made.

Drawing Frame. — The drawing frame of 1824 was improved, and the improvements patented, in 1835, and others again in 1842. That of 1824 is known in Germany and France, and generally in use. The laps from the carding engine lap-machine are put upon delivering rollers, behind a set of drawing rollers, and from them delivered upon a belt or trough, and again formed into laps similar to those from the carding engines. The next operation formed the laps into untwisted rovings, and the next again into smaller untwisted rovings, or rovings with false twist in them as infringed upon by Dyer. The false twist was rather objectionable, and in his patent of 1835 he put a number of rovings on the same bobbin, with left and right permanent twist in them. This does very well; there is, however, a little objection to that place in which the twist changes from right to left when it comes to the last operation before spinning. In his patent of 1838, and particularly in that of 1842, he confined the left and right-hand twist to the drawing frame, when he converts two laps into one roving, and forms a roller or bobbin of 14 inches diameter and 15 inches broad, with six separate and twisted rovings wound upon it. (See *figs.* 1328, and 1329.) The twist is given by tubes in two directions, so that it remains in it (see *fig.* 1329.) the tube turns in the same direction, while the roving advances 4 or 5 inches, and then turns in the other direction. These laps or bobbins are then placed behind a machine, which he calls a coil-frame, the most important arrangement of which he claimed already in his patent of 1835. It consists of a slot with a travelling spout, without which the coils cannot be formed under pressure. Coiling in cotton cannot be claimed, as it was done in the first system of cotton spinning.

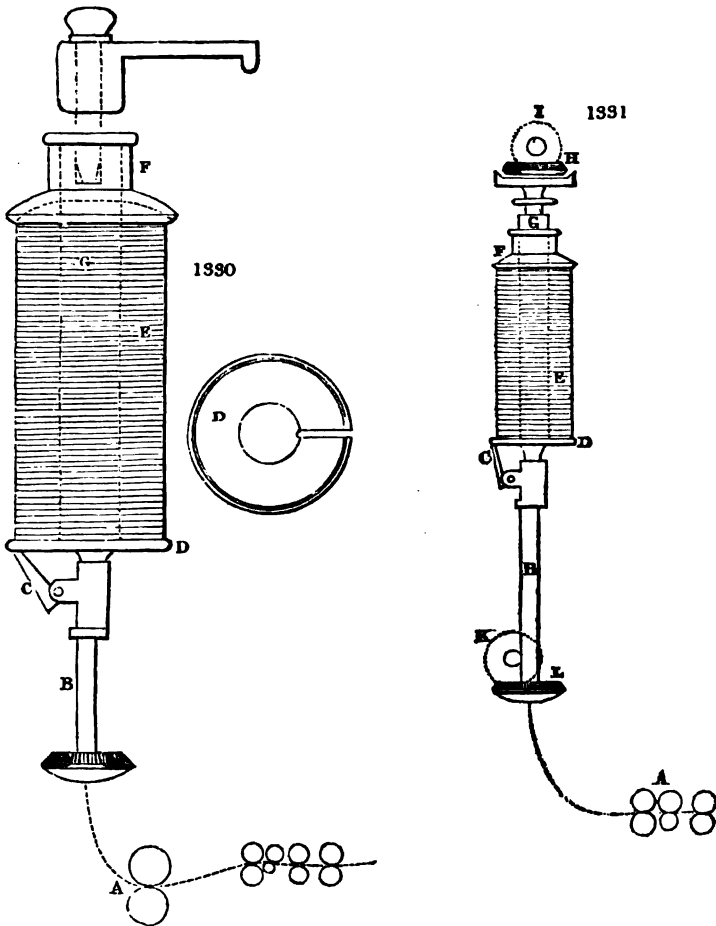
Coil Frame. — The bobbins (*fig.* 1328.) are placed behind this machine, and two ends from the bobbin are passed through the drawing rollers and formed into one untwisted sliver or roving in the following manner: — When the cotton has passed through the drawing rollers (see *fig.* 1330.) and calender rollers, *A*, it is passed through the tube, *a*, and the finger, *c*; the spindle with its disc, *b*, revolves in such a proportion as to take up the cotton which proceeds from the calender rollers, *A*, and cause the rovings to be laid down in a spiral line closely one by one, and as the rollers, *A*, work at a regular speed, it is evident that the motion of the finger, *c*, and the speed of the tube *a*, must vary accordingly. The coil, *x*, is stationary, and is pressed by the lid or top, *v*, which slides up the spindle, *a*, made of tin plate. The cotton enters through the slot, *x*, in *fig.* *b*. It is quite evident that the finger, *c*, and spindle, *a*, only perform one and the same varying motion, which is repeated at every fresh layer, and the soil is thus built from below; it is about 8 inches in diameter and 18 inches high when compressed,



Patents of 1835, 1838, and 1842.

and contains $4\frac{1}{2}$ lbs. of cotton. Mr. Bodmer has several modes of forming these coils, but one only is shown here. These coils are placed behind the twist coil frames in half cans or partly open ones or troughs, or behind a winding machine, where they are wound upon rollers side by side, like the lap or bobbin shown in the drawing frame, and placed behind the twist coil frame in this state.

Twist Coil Frame. — This frame forms rovings into coils similar to those above explained, with this difference, that the rovings are fine, say, from 1 to 10 hanks per pound, and regularly twisted; their diameter varies from $2\frac{1}{4}$ to 5 inches. The same machines produce rovings more or less fine, but the diameter of the coils does not differ.



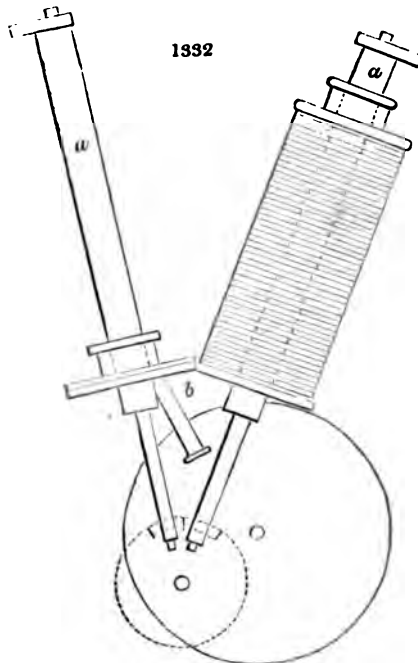
Patents of 1838 and 1842.

Patents of 1838 and 1842.

The difference of this machine from that above described consists in the dimensions of their parts, and in its having the spindle, *a*, and the lid or top, *r*, revolving, as well as the tube, *a*. (See fig. 1331.) In this machine the motion of the spindle, *a*, is uniform: the spindle, *a*, however, is connected by the bevel wheels *x* and *l*, with a differential motion at the end of the frame, with which the motion of the finger, *c*, corresponds. The skew wheels, *x* and *l*, are connected with the drawing rollers, *a*. The speed of the tube, *a*, and the spindle, *a*, are so proportioned, that while the spindle, *a*, performs one revolution, and therefore puts one twist into the roving, the tube, *a*, also performs one revolution, missing so much as will be required to pass through the slot in the cap or disc, *d*, and lay on it as much of the roving as proceeds from the rollers, *a*, and in which one twist is contained. Of course the twist of these rovings can be adapted to their fineness and varied; but it is evident that, on account of the regularity of the machine and its simplicity of movement, the rovings can never be stretched, and much less twist can be put into them than can be put in the common fly frames. These coils are put behind the spinning machines on shelves or in small cans, open in front; or they are wound from 24 to 72 ends upon bobbins, and placed upon unlap rollers behind the spinning frames.

Coiling Machine for Carding Engines and Drawing Frames.—These are simple machines, which may be applied to carding engines or drawing frames of any description. They form large coils, 9 inches in diameter and 22 inches long, when on the

machine. There are two spindles, *a*, (see *fig.* 1332.) on each machine, for the purpose of doffing without stopping the drawing frame and carding engines. When one coil is

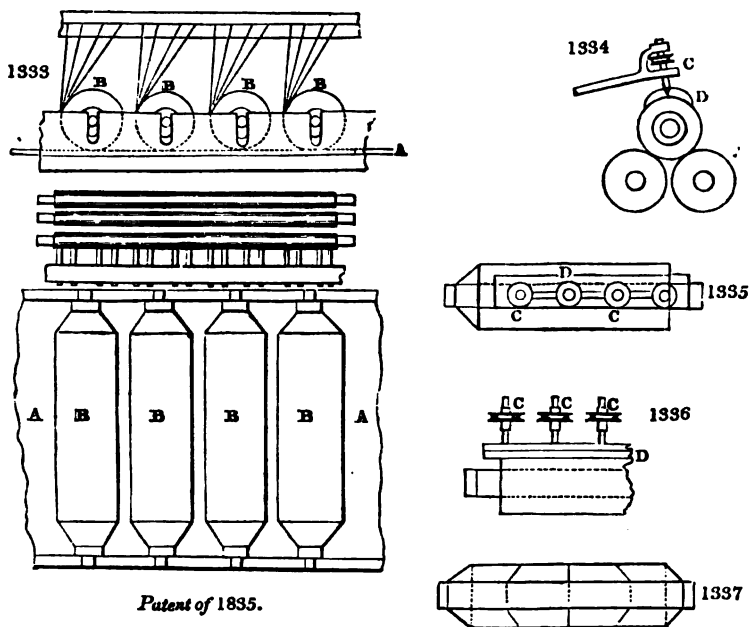


Patents of 1842.

filled, the finger, *b*, is just brought over to the other spindle, so that the full coil is stopped and the new one begins to be formed without the slightest interruption of the machine.

Mr. B. forms coils in various ways, also in cans; but this description is sufficient to show the application of this mode of winding up bands or rovings. Several of the above-described machines are adopted with equal success to wool and flax. In his patents of 1835, 1837, and 1838, he shows several modes of applying his system to cotton and other machinery. He winds directly from the carding engines the slivers separately upon long bobbins, and he gives them twist in two directions, for the purpose of uniting the fibres to some extent, so that they not only come off the bobbins without sticking to one another, but also that they may draw smoother. He also showed a machine, by which several rovings, say 4 or more, are put upon the same bobbin with conical ends; these bobbins are placed behind the mules or throstles, and are unwound by a belt or strap running parallel with the fluted rollers of the spinning machine as seen in *fig.* 1333. The belt or band, *a*, is worked in a similar way to that described in his former patent, and the bobbins, *b*, rest upon and revolve upon their surface, exactly according to the speed of the belt. It is quite evident that the whole set of rovings must be unwound exactly at the same speed, and that no stretching can take place. He can put real and reversed twist in these rovings as well as false twist only. The most important feature in the roving machine is a metal plate, in which a slot is formed through which the rovings pass; this slot is seen in *figs.* 1334, 1335, and 1336. The cotton when coming from the drawing rollers is passed through the twisters, *c*, and through the slot in the plate, *d*. Thus he is enabled to put any convenient number of neatly formed and perfectly separate coils upon the wooden barrel or bobbin. The bobbin formed upon these machines is represented in *fig.* 1337., and the conical ends are formed by a mechanism, by which the twisters, *c*, are caused to approach a little more to one another, after each layer of rovings has been coiled round the barrel: the section of the bobbin is therefore like that shown in *fig.* 1337. He makes use of exactly the same arrangement, viz. a finger travelling along a slot in a plate, for the purpose of forming the coils, which has been already described.

Rovings wound upon bobbins by means of tubes revolving in one direction are cer-



Patent of 1835.

tainly not so fit for spinning as rovings into which a small degree of twist is put. The tube by which a twist is put in on one side and taken out at the other curls or ruffles the cotton, and causes it to spread out as it passes between the rollers, while rovings with a little permanent twist in them are held together in the process of drawing, and thus produce smooth yarn. To remedy the evil above described, when untwisted rovings are used, he causes the spouts or guides, through which the rovings pass into or between the drawing rollers, to revolve slowly first in one, and then in the other direction, and thus puts a certain quantity of twist into the rovings while they are being prepared for spinning. Two modes of performing this operation are clearly described in his patent of 1835.

There is a little defect in the working of the rovings with reversed twist when too much or too little twist is put in them, or when the winding machine is not kept in good order. This defect proceeds from the change in the twist of the roving seen at *A*, *fig.* 1338.; in this place the twist is not like that at *x*, and it would, in some parts of the

1338



yarn, be detected under circumstances just described. In cases where double rovings are used, the twisters are so arranged as to put the twist in the rovings, as shown in *fig.* 1339.: in this case the reversing place of one roving meets the twisted place of the other, and the fault is completely rectified.

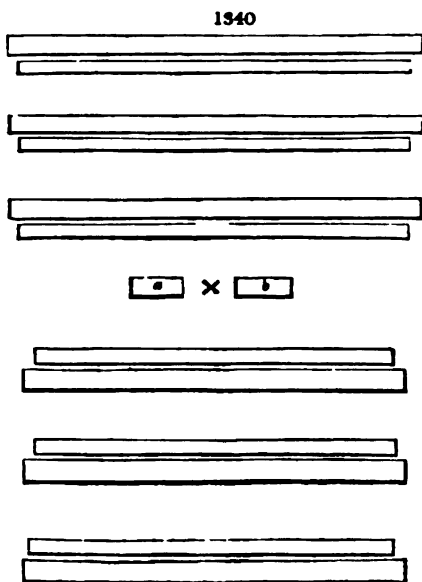
1339



The preceding description gives an idea of Mr. Bodmer's admirable system of preparing and spinning cotton, wool, flax, &c., and of the several processes; it would be superfluous to describe the several machines, or the details of the same, as exhibited in his patents.

In his patent of 1838, he specifies a self-actor, namely a machine in itself, which can be attached to 2, 3, or even 4 mules of almost any convenient number of spindles. The mules are previously stripped of all their mechanism except the rollers and their wheels, the carriage and spindles; all the other movements ordinarily coun-

bined with the mule are contained in the machine, which is placed between a set of mules, as seen in *fig. 1340.*; *a* and *b*, the self-actors, to each of which 3 mules are



yoked, and which are connected by bands and shafts with the self-actor, or rather partly self-actor. A girl of fifteen or sixteen years old stands at *x* between *a* and *b*, and never leaves her place except, perhaps, for aiding in doffing or in banding the spindles. The gearing of the room acts by means of straps upon the machines *a* and *b*, and from these machines all the movements are given to the six mules, namely, the motion of the rollers, the spindles, the drawing out of the carriage, the after draft, &c. When the carriages are to be put up, the girl takes hold of two levers of the machine *a*, and by moving them in certain proportions, acts upon two cones and pulleys, and thus causes, in the most easy and certain manner, the carriages to run in and the yarn to be wound on the spindles. The first machine Mr. B. made for this purpose was completely self-acting, but he found very soon that the mechanism was more complicated and apt to go out of order than that of the above-described machine; and

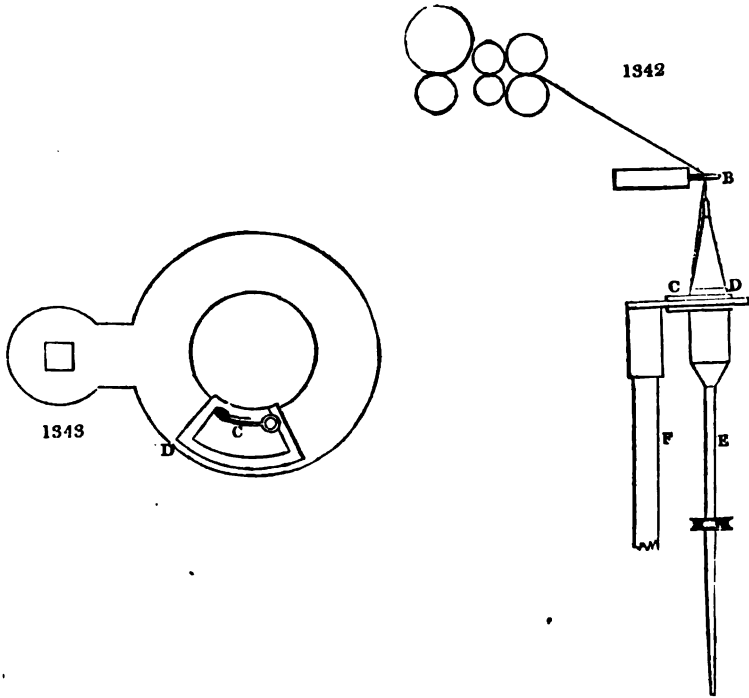
as it is necessary to have a girl of a certain age to watch over the pieces for a certain number of mules, he preferred the simplified machine; placing the girl near these machines, from whence the whole set of mules attached to the same can be overlooked, as the creels behind the mules are not wanted in his system, this impediment to the sight of the girl would be removed. He schemed these machines for the purpose of altering, at a trifling expense, the common mules into self-actors; they are equally good for any numbers of yarn.

Bastard Frame. — In his patent of 1838 and 1842, we find the description of a very simple bastard frame, namely, a throistle with mule spindles, forming cops, as seen in *fig. 1341.*, and wound so hard that they can be handled about without any danger of spoiling them; in the same dimensions they contain one third more yarn than the best cops of self-actors. The machine is extremely simple; but owing to some circumstances in the construction of the winders and plates, he has not been able to spin advantageously upon large machines above No. 20's.

He has spun on it No. 56, and most beautiful yarn. The quantity this machinery produces is nearly one third more than the best self-actor, on an equal number of spindles, and the yarn and cops are much superior. Of course there is a copping motion connected with the machine: the winding, however, is continuous, as well as the twisting, and *figs. 1342.* and *1343.* will give the reader an idea of the frame. The yarn coming from the rollers, *A*, goes through an eye, *B*, to the wire, *C*, fixed in the flyer, *D*, and from thence on to the mule spindle, *E*: as the spindle revolves, the flyer is dragged along, and by its centrifugal power winds the yarn tight upon the spindles.

SPIRIT OF AMMONIA, is, properly speaking, alcohol combined with ammonia gas; but the term is often applied to water of ammonia.

SPIRITS, VINOUS. This subject has been fully discussed in the articles **ALCOHOL**, **DISTILLATION**, and **FERMENTATION**. I have shown that the progressive increase of alcohol in the wash tends progressively to prevent the conversion of the wort into spirit, or checks the fermenting process, though a great deal of fermentable matter remains unchanged. Mr. Sheridan has sought to remove this obstacle to the thorough transmutation of saccharine matter into alcohol, by drawing off the spirit as it is formed. For this purpose he ferments his wash in close tuns connected with a powerful air-pump worked by machinery, thus continually removing the carbonic acid as it is formed, and maintaining a diminished pressure under which the alcohol readily distils at a temperature of 120° or 130° F. He finds that this degree of heat is not injurious to the



Patents of 1838 and 1842.

fermentation, provided that it be communicated by the air of a stove-room, and not by water or steam pipes traversing the liquid, which would inevitably scald or seeth the particles in succession, and thereby extinguish the fermenting principle.

By the above ingenious plan, Mr. Sheridan tells me he has obtained 28 gallons of proof spirit from a quarter of grain, instead of the average product, 21, being an increase of 25 per cent. The experiment was tried upon a considerable scale at Messrs. Currie's great distillery near London; but could not be established as a mode of manufacture, on account of the excise laws, which prohibit the distillers from carrying on the two processes of fermentation and distillation at the same time.

Consumption of Spirits. — According to a return recently made, the total number of gallons of proof spirits distilled in the United Kingdom during the year ending January 5, 1850, was 24,775,128, distributed among the three kingdoms thus: — England, 5,573,411 gallons, of which 5,365,600 were from malt with unmalted grain, 17,337 from sugar or molasses with unmalted grain, 13,941 from sugar, and 176,553 from molasses; Scotland, 10,846,634 gallons, of which 6,058,086 were from malt only, and 4,788,554 from malt with unmalted grain; Ireland, 8,355,883 gallons, of which 85,756 were from malt only, 8,047,077 from malt with unmalted grain, and 222,250 from sugar or molasses with unmalted grain. The number of gallons of proof spirits on which duty was paid for home consumption in the United Kingdom was 22,962,012, the total amount of duty being 5,747,218*l.* 1*s.*, distributed as follows: — England, 675,036 gallons from malt only, 8,166,226 from malt mixed with unmalted grain, 14,740 from sugar, and 177,052 from molasses; total, 9,053,676 gallons, on which 3,546,023*l.* 2*s.* duty was paid, at the rate of 7*s.* 10*d.* per gallon; Scotland, 4,950,736 gallons from malt only, 1,984,115 from malt mixed with unmalted grain, and 152 from sugar; total, 6,935,003 gallons, on which the duty, at 3*s.* 8*d.* per gallon, amounted to 1,371,417*l.* 4*s.* 4*d.*; Ireland, 452,468 gallons from malt only, 6,404,770 from malt mixed with unmalted grain, 112,308 from sugar or molasses with unmalted grain, and 3,787 from sugar; total, 6,973,333 gallons, yielding, at the rate of 2*s.* 8*d.* per gallon, an amount of duty equal to 929,777*l.* 14*s.* 8*d.*

Correspondence between Specific Gravity and Per Centa. over Proof at 60° Fahr.

| Specific Gravity. | Per Cent. over Proof. | Specific Gravity. | Per Cent. over Proof. | Specific Gravity. | Per Cent. over Proof. | Specific Gravity. | Per Cent. over Proof. |
|-------------------|-----------------------|-------------------|-----------------------|-------------------|-----------------------|-------------------|-----------------------|
| ·8186 | 67·0 | ·8435 | 51·7 | ·8748 | 22·4 | ·9066 | 11·4 |
| ·8160 | 66·8 | ·8459 | 51·5 | ·8751 | 22·2 | ·9060 | 11·1 |
| ·8163 | 66·6 | ·8463 | 51·3 | ·8755 | 22·0 | ·9064 | 10·8 |
| ·8167 | 66·5 | ·8465 | 51·1 | ·8758 | 22·7 | ·9067 | 10·6 |
| ·8170 | 66·3 | ·8469 | 50·9 | ·8762 | 22·4 | ·9071 | 10·3 |
| ·8174 | 66·1 | ·8473 | 50·7 | ·8765 | 22·2 | ·9075 | 10·0 |
| ·8178 | 65·6 | ·8476 | 50·5 | ·8769 | 22·0 | ·9079 | 9·7 |
| ·8181 | 65·6 | ·8480 | 50·3 | ·8773 | 21·7 | ·9083 | 9·4 |
| ·8185 | 65·6 | ·8483 | 50·1 | ·8776 | 21·5 | ·9086 | 9·2 |
| ·8188 | 65·5 | ·8486 | 49·9 | ·8779 | 21·3 | ·9089 | 8·9 |
| ·8192 | 65·3 | ·8490 | 49·7 | ·8783 | 21·0 | ·9093 | 8·6 |
| ·8196 | 65·1 | ·8493 | 49·5 | ·8786 | 20·8 | ·9097 | 8·3 |
| ·8199 | 65·0 | ·8496 | 49·3 | ·8790 | 20·6 | ·9100 | 8·0 |
| ·8203 | 64·8 | ·8499 | 49·1 | ·8793 | 20·3 | ·9104 | 7·7 |
| ·8206 | 64·7 | ·8503 | 48·9 | ·8797 | 20·0 | ·9107 | 7·4 |
| ·8210 | 64·5 | ·8506 | 48·7 | ·8800 | 20·8 | ·9111 | 7·1 |
| ·8214 | 64·3 | ·8510 | 48·5 | ·8804 | 20·5 | ·9115 | 6·8 |
| ·8218 | 64·1 | ·8513 | 48·3 | ·8807 | 20·2 | ·9118 | 6·5 |
| ·8221 | 64·0 | ·8516 | 48·0 | ·8811 | 20·0 | ·9122 | 6·2 |
| ·8224 | 63·8 | ·8520 | 47·8 | ·8814 | 20·8 | ·9126 | 5·9 |
| ·8227 | 63·6 | ·8523 | 47·6 | ·8818 | 20·5 | ·9130 | 5·6 |
| ·8231 | 63·4 | ·8527 | 47·4 | ·8822 | 20·2 | ·9134 | 5·3 |
| ·8234 | 63·2 | ·8530 | 47·2 | ·8826 | 20·0 | ·9137 | 5·0 |
| ·8238 | 63·1 | ·8533 | 47·0 | ·8829 | 20·8 | ·9141 | 4·8 |
| ·8242 | 62·9 | ·8537 | 46·8 | ·8833 | 20·5 | ·9145 | 4·5 |
| ·8245 | 62·7 | ·8540 | 46·6 | ·8836 | 20·3 | ·9148 | 4·2 |
| ·8249 | 62·5 | ·8543 | 46·4 | ·8840 | 20·0 | ·9152 | 3·9 |
| ·8252 | 62·3 | ·8547 | 46·2 | ·8843 | 20·8 | ·9156 | 3·6 |
| ·8256 | 62·2 | ·8550 | 46·0 | ·8847 | 20·5 | ·9159 | 3·3 |
| ·8259 | 62·0 | ·8553 | 45·8 | ·8850 | 20·2 | ·9163 | 3·0 |
| ·8263 | 61·8 | ·8556 | 45·6 | ·8854 | 20·0 | ·9167 | 2·7 |
| ·8266 | 61·6 | ·8560 | 45·4 | ·8858 | 20·8 | ·9170 | 2·4 |
| ·8270 | 61·4 | ·8563 | 45·2 | ·8861 | 20·5 | ·9174 | 2·1 |
| ·8273 | 61·3 | ·8566 | 45·0 | ·8865 | 20·2 | ·9178 | 1·9 |
| ·8277 | 61·1 | ·8570 | 44·8 | ·8869 | 20·0 | ·9182 | 1·6 |
| ·8280 | 60·9 | ·8573 | 44·6 | ·8872 | 20·8 | ·9185 | 1·3 |
| ·8284 | 60·7 | ·8577 | 44·4 | ·8876 | 20·5 | ·9189 | 1·0 |
| ·8287 | 60·6 | ·8581 | 44·2 | ·8879 | 20·3 | ·9192 | 0·7 |
| ·8291 | 60·4 | ·8583 | 43·9 | ·8883 | 20·0 | ·9196 | 0·4 |
| ·8294 | 60·3 | ·8587 | 43·7 | ·8886 | 20·8 | ·9200 | Proof. |
| ·8298 | 60·0 | ·8590 | 43·5 | ·8890 | 20·5 | Under Proof. | |
| ·8301 | 59·8 | ·8594 | 43·3 | ·8894 | 20·2 | ·9204 | 0·3 |
| ·8305 | 59·6 | ·8597 | 43·1 | ·8897 | 20·0 | ·9207 | 0·6 |
| ·8308 | 59·5 | ·8601 | 42·8 | ·8901 | 22·7 | ·9210 | 0·9 |
| ·8312 | 59·3 | ·8604 | 42·6 | ·8904 | 22·5 | ·9214 | 1·3 |
| ·8315 | 59·1 | ·8608 | 42·4 | ·8908 | 22·2 | ·9218 | 1·6 |
| ·8319 | 58·9 | ·8611 | 42·2 | ·8912 | 21·9 | ·9222 | 1·9 |
| ·8322 | 58·7 | ·8615 | 42·0 | ·8915 | 21·7 | ·9226 | 2·2 |
| ·8326 | 58·6 | ·8618 | 41·7 | ·8919 | 21·4 | ·9229 | 2·5 |
| ·8329 | 58·4 | ·8622 | 41·5 | ·8922 | 21·2 | ·9233 | 2·8 |
| ·8333 | 58·2 | ·8625 | 41·3 | ·8926 | 20·9 | ·9237 | 3·1 |
| ·8336 | 58·0 | ·8629 | 41·1 | ·8930 | 20·6 | ·9241 | 3·4 |
| ·8340 | 57·8 | ·8632 | 40·9 | ·8933 | 20·4 | ·9244 | 3·7 |
| ·8344 | 57·7 | ·8636 | 40·6 | ·8937 | 20·1 | ·9248 | 4·0 |
| ·8347 | 57·5 | ·8639 | 40·4 | ·8940 | 19·9 | ·9252 | 4·4 |
| ·8351 | 57·3 | ·8643 | 40·2 | ·8944 | 19·6 | ·9255 | 4·7 |
| ·8354 | 57·1 | ·8646 | 40·0 | ·8948 | 19·3 | ·9259 | 5·0 |
| ·8358 | 56·9 | ·8650 | 39·8 | ·8951 | 19·1 | ·9263 | 5·3 |
| ·8362 | 56·8 | ·8653 | 39·5 | ·8955 | 18·8 | ·9267 | 5·7 |
| ·8365 | 56·6 | ·8657 | 39·3 | ·8959 | 18·6 | ·9270 | 6·0 |
| ·8369 | 56·4 | ·8660 | 39·1 | ·8962 | 18·3 | ·9274 | 6·4 |
| ·8372 | 56·2 | ·8664 | 38·9 | ·8966 | 18·0 | ·9278 | 6·7 |
| ·8376 | 56·0 | ·8667 | 38·7 | ·8970 | 17·7 | ·9282 | 7·0 |
| ·8379 | 55·9 | ·8671 | 38·4 | ·8974 | 17·5 | ·9286 | 7·3 |
| ·8383 | 55·7 | ·8674 | 38·2 | ·8977 | 17·3 | ·9291 | 7·7 |
| ·8386 | 55·5 | ·8678 | 38·0 | ·8981 | 17·0 | ·9295 | 8·0 |
| ·8390 | 55·3 | ·8681 | 37·8 | ·8985 | 16·8 | ·9299 | 8·3 |
| ·8393 | 55·1 | ·8685 | 37·6 | ·8989 | 16·4 | ·9302 | 8·6 |
| ·8396 | 55·0 | ·8688 | 37·3 | ·8992 | 16·1 | ·9306 | 9·0 |
| ·8400 | 54·8 | ·8692 | 37·1 | ·8996 | 15·9 | ·9310 | 9·3 |
| ·8403 | 54·6 | ·8695 | 36·9 | ·9000 | 15·6 | ·9314 | 9·7 |
| ·8407 | 54·4 | ·8699 | 36·7 | ·9004 | 15·3 | ·9318 | 10·0 |
| ·8410 | 54·2 | ·8702 | 36·4 | ·9008 | 15·0 | ·9322 | 10·3 |
| ·8413 | 54·1 | ·8706 | 36·2 | ·9011 | 14·8 | ·9326 | 10·7 |
| ·8417 | 53·9 | ·8709 | 35·9 | ·9015 | 14·5 | ·9329 | 11·0 |
| ·8420 | 53·7 | ·8713 | 35·7 | ·9019 | 14·2 | ·9333 | 11·4 |
| ·8424 | 53·5 | ·8716 | 35·5 | ·9023 | 13·9 | ·9337 | 11·7 |
| ·8427 | 53·3 | ·8719 | 35·2 | ·9026 | 13·6 | ·9341 | 12·1 |
| ·8431 | 53·1 | ·8723 | 35·0 | ·9031 | 13·4 | ·9345 | 12·4 |
| ·8434 | 52·9 | ·8727 | 34·7 | ·9034 | 13·1 | ·9349 | 12·8 |
| ·8438 | 52·7 | ·8730 | 34·5 | ·9038 | 12·8 | ·9353 | 13·1 |
| ·8441 | 52·5 | ·8734 | 34·3 | ·9041 | 12·5 | ·9357 | 13·5 |
| ·8445 | 52·3 | ·8737 | 34·1 | ·9045 | 12·2 | ·9360 | 13·9 |
| ·8448 | 52·1 | ·8741 | 33·8 | ·9049 | 12·0 | ·9364 | 14·2 |
| ·8452 | 51·9 | ·8744 | 33·6 | ·9053 | 11·7 | ·9368 | 14·6 |

SPIRITS.

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Table—continued.

| Specific Gravity. | Per Cent. under Proof. | Specific Gravity. | Per Cent. under Proof. | Specific Gravity. | Per Cent. under Proof. | Specific Gravity. | Per Cent. under Proof. |
|-------------------|------------------------|-------------------|------------------------|-------------------|------------------------|-------------------|------------------------|
| ·9372 | 14·9 | ·9530 | 31·0 | ·9685 | 52·2 | ·9846 | 79·2 |
| ·9376 | 15·3 | ·9534 | 31·4 | ·9689 | 52·9 | ·9850 | 79·8 |
| ·9380 | 15·7 | ·9539 | 31·1 | ·9693 | 53·3 | ·9854 | 80·4 |
| ·9384 | 16·0 | ·9542 | 32·3 | ·9697 | 54·2 | ·9858 | 81·1 |
| ·9388 | 16·4 | ·9546 | 32·8 | ·9701 | 54·8 | ·9862 | 81·7 |
| ·9392 | 16·7 | ·9550 | 33·2 | ·9705 | 55·5 | ·9866 | 82·3 |
| ·9396 | 17·1 | ·9553 | 33·7 | ·9709 | 56·2 | ·9870 | 82·9 |
| ·9399 | 17·5 | ·9557 | 34·2 | ·9713 | 56·9 | ·9874 | 83·5 |
| ·9403 | 17·8 | ·9561 | 34·6 | ·9718 | 57·6 | ·9878 | 84·0 |
| ·9407 | 18·2 | ·9565 | 35·1 | ·9722 | 58·3 | ·9882 | 84·6 |
| ·9411 | 18·5 | ·9569 | 35·6 | ·9726 | 59·0 | ·9886 | 85·2 |
| ·9415 | 18·9 | ·9573 | 36·1 | ·9730 | 59·7 | ·9890 | 85·8 |
| ·9419 | 19·3 | ·9577 | 36·6 | ·9734 | 60·4 | ·9894 | 86·3 |
| ·9422 | 19·7 | ·9580 | 37·1 | ·9738 | 61·1 | ·9898 | 86·9 |
| ·9426 | 20·0 | ·9584 | 37·6 | ·9742 | 61·8 | ·9902 | 87·4 |
| ·9430 | 20·4 | ·9588 | 38·1 | ·9746 | 62·5 | ·9906 | 88·0 |
| ·9434 | 20·8 | ·9592 | 38·6 | ·9750 | 63·2 | ·9910 | 88·5 |
| ·9437 | 21·2 | ·9596 | 39·1 | ·9754 | 63·9 | ·9914 | 89·1 |
| ·9441 | 21·6 | ·9599 | 39·6 | ·9758 | 64·6 | ·9918 | 89·6 |
| ·9445 | 21·9 | ·9603 | 40·1 | ·9762 | 65·3 | ·9922 | 90·2 |
| ·9448 | 22·3 | ·9607 | 40·6 | ·9766 | 66·0 | ·9926 | 90·7 |
| ·9452 | 22·7 | ·9611 | 41·2 | ·9770 | 66·7 | ·9930 | 91·2 |
| ·9456 | 23·1 | ·9615 | 41·7 | ·9774 | 67·4 | ·9934 | 91·7 |
| ·9460 | 23·5 | ·9619 | 42·2 | ·9778 | 68·0 | ·9938 | 92·3 |
| ·9464 | 23·9 | ·9623 | 42·8 | ·9782 | 68·7 | ·9942 | 92·8 |
| ·9468 | 24·3 | ·9627 | 43·3 | ·9786 | 69·4 | ·9946 | 93·3 |
| ·9472 | 24·7 | ·9631 | 43·9 | ·9790 | 70·1 | ·9950 | 93·8 |
| ·9476 | 25·1 | ·9635 | 44·4 | ·9794 | 70·8 | ·9954 | 94·3 |
| ·9480 | 25·5 | ·9639 | 45·0 | ·9798 | 71·4 | ·9958 | 94·9 |
| ·9484 | 25·9 | ·9642 | 45·5 | ·98 2 | 72·1 | ·9962 | 95·4 |
| ·9488 | 26·3 | ·9646 | 46·1 | ·9806 | 72·8 | ·9966 | 95·9 |
| ·9492 | 26·7 | ·9650 | 46·7 | ·9810 | 73·5 | ·9970 | 96·4 |
| ·9496 | 27·1 | ·9654 | 47·3 | ·9814 | 74·1 | ·9974 | 96·8 |
| ·9499 | 27·5 | ·9657 | 47·9 | ·9816 | 74·8 | ·9978 | 97·3 |
| ·9503 | 28·0 | ·9661 | 48·5 | ·9822 | 75·4 | ·9982 | 97·7 |
| ·9507 | 28·4 | ·9665 | 49·1 | ·9826 | 76·1 | ·9986 | 98·2 |
| ·9511 | 28·8 | ·9669 | 49·7 | ·9830 | 76·7 | ·9990 | 98·7 |
| ·9515 | 29·2 | ·9674 | 50·2 | ·9834 | 77·3 | ·9993 | 99·1 |
| ·9519 | 29·7 | ·9677 | 51·0 | ·9838 | 78·0 | ·9997 | 99·6 |
| ·9522 | 30·1 | ·9681 | 51·6 | ·9842 | 78·6 | 1·0000 | 100·0 |

The total number of gallons of proof spirits imported into England in the year ending January 5, 1850, from Scotland, amounted to 2,651,529 gallons, of which 673,342 were distilled from malt only, and 1,978,187 from a mixture of malt with unmalted grain; and the total amount of duty paid thereon, at the rate of 7s. 10d. per gallon, was 1,038,515*l.* 10s. 6d., being 513,330*l.* 8s. on removal from bond, and 525,185*l.* 2s. 6d. after arrival at the place of destination. The number of gallons imported from Ireland was 890,021, of which 1,694 were from malt only, 884,772 from malt with unmalted grain, 3,285 from sugar or molasses with grain, and 270 from sugar; and the total amount of duty paid was 348,591*l.* 11s. 2d., being 118,912*l.* 7s. 6d. on removal from bond, and 229,679*l.* 3s. 8d. after arrival at the place of destination. The number of gallons imported from Scotland into Ireland was 766,405, of which 396,064 were from malt only, 370,205 from malt mixed with grain, and 136 from sugar, the amount of duty paid, at the rate of 2s. 8d. being 102,187*l.* 6s. 8d., levied after arrival at the place of destination. The quantity imported from Ireland into Scotland was 12,580 gallons, of which 12,428 were from malt with grain, and 152 from sugar, and the duty paid thereon, at the rate of 3s. 8d., amounted to 2,306*l.* 6s. 8d.

SPIRIT OF WINE; Alcohol.

SPONGE (*Sponge*, Fr.; *Schwamm*, Germ.) is a cellular fibrous tissue produced by small animals, almost imperceptible, called polypi by naturalists, which live in the sea. This tissue is said to be covered in its recent state with a kind of semi-fluid thin coat of animal jelly, susceptible of a slight contraction or trembling on being touched; which is the only symptom of vitality displayed by the sponge. After death, this jelly disappears, and leaves merely the sponge; formed by the combination of a multitude of small capillary tubes, capable of receiving water in their interior, and of becoming thereby distended. Sponges occur attached to stones at the bottom of the sea; and abound particularly upon the shores of the islands in the Grecian Archipelago. Although analogous in their origin to coral, sponges are quite different in their nature; the former being composed almost entirely of carbonate of lime; while the latter are formed of the same elements as animal matters, and afford, on distillation, a considerable quantity of ammonia.

Dilute sulphuric acid has been recommended for bleaching sponges, after the calcareous impurities have been removed by muriatic acid. Chlorine water answers better.

SPOON MANUFACTURE. See *STAMPING OF METALS*.

STAINED GLASS. When certain metallic oxides or chlorides, ground up with proper fluxes, are painted upon glass, their colours fuse into its surface at a moderate heat, and make durable pictures, which are frequently employed in ornamenting the windows of churches as well as of other public and private buildings. The colours of stained glass are all transparent, and are therefore to be viewed only by transmitted light. Many metallic pigments, which afford a fine effect when applied cold on canvass or paper, are so changed by vitreous fusion as to be quite inapplicable to painting in stained glass.

The glass proper for receiving these vitrifying pigments should be colourless, uniform, and difficult of fusion; for which reason crown glass, made with little alkali, or with kelp, is preferred. When the design is too large to be contained on a single pane, several are fitted together, and fixed in a bed of soft cement while painting, and then taken asunder to be separately subjected to the fire. In arranging the glass pieces, care must be taken to distribute the joinings so that the lead frame-work may interfere as little as possible with the effect.

A design must be drawn upon paper, and placed beneath the plate of glass; though the artist cannot regulate his tints directly by his pallet, but by specimens of the colours producible from his pallet pigments after they are fired. The upper side of the glass being sponged over with gum-water affords, when dry, a surface proper for receiving the colours, without the risk of their running irregularly, as they would be apt to do on the slippery glass. The artist first draws on the plate, with a fine pencil, all the traces which mark the great outlines and shades of the figures. This is usually done in black, or, at least, some strong colour, such as brown, blue, green, or red. In laying on these, the painter is guided by the same principles as the engraver, when he produces the effect of light and shade by dots, lines, or hatches; and he employs that colour to produce the shades, which will harmonize best with the colour which is to be afterwards applied; but for the deeper shades, black is in general used. When this is finished, the whole picture will be represented in lines or hatches similar to an engraving finished up to the highest effect possible; and afterwards, when it is dry, the vitrifying colours are laid on by means of larger hair pencils; their selection being regulated by the burnt specimen tints. When he finds it necessary to lay two colours adjoining, which are apt to run together in the kiln, he must apply one of them to the back of the glass. But the few principal colours to be presently mentioned, are all fast colours, which do not run, except the yellow, which must therefore be laid on the opposite side. After colouring, the artist proceeds to bring out the lighter effects by taking off the colour in the proper place, with a goose quill cut like a pen without a slit. By working this upon the glass, he removes the colour from the parts where the lights should be the strongest; such as the hair, eyes, the reflection of bright surfaces and light parts of draperies. The blank pen may be employed either to make the lights by lines, or hatches and dots, as is most suitable to the subject.

By the metallic preparations now laid upon it, the glass is made ready for being fired, in order to fix and bring out the proper colours. The furnace or kiln best adapted for this purpose, is similar to that used by enamellers. See *ENAMEL*, and the *Glaze-kiln*, under *POTTERY*. It consists of a muffle or arch of fire-clay or pottery, so set over a fireplace, and so surrounded by flues, as to receive a very considerable heat within, in the most equable and regular manner; otherwise some parts of the glass will be melted; while, on others, the superficial film of colours will remain unvitrified. The mouth of the muffle, and the entry for introducing fuel to the fire, should be on opposite sides, to prevent as much as possible the admission of dust into the muffle, whose mouth should be closed with double folding-doors of iron, furnished with small peep-holes, to allow the artist to watch the progress of the staining, and to withdraw small trial slips of glass, painted with the principal tints used in the picture.

The muffle must be made of very refractory fire-clay, flat at its bottom, and only 5 or 6 inches high, with such an arched top as may make the roof strong, and so close on all sides as to exclude entirely the smoke and flame. On the bottom of the muffle a smooth bed of sifted lime, freed from water, about half an inch thick, must be prepared for receiving the pane of glass. Sometimes several plates of glass are laid over each other with a layer of dry pulverulent lime between each. The fire is now lighted, and most gradually raised, lest the glass should be broken; and after it has attained to its full heat, it must be kept up for 3 or 4 hours, more or less, according to the indications of the trial slips; the yellow colour being principally watched, as it is found to be the best criterion of the state of the others. When the colours are properly burnt in, the fire is suffered to die away, so as to anneal the glass.

STAINED-GLASS PIGMENTS.

Flesh colour. — Take an ounce of red lead, two ounces of red enamel (Venetian glass enamel, from alum and copperas calcined together), grind them to fine powder, and work this up with spirits (alcohol) upon a hard stone. When slightly baked, this produces a fine flesh colour.

Black colour. — Take $14\frac{1}{2}$ ounces of smithy scales of iron, mix them with two ounces of white glass (crystal), an ounce of antimony, and half an ounce of manganese; pound and grind these ingredients together with strong vinegar. A brilliant black may also be obtained by a mixture of cobalt blue with the oxides of manganese and iron. Another black is made from three parts of crystal glass, two parts of oxide of copper, and one of (glass of) antimony worked up together, as above.

Brown colour. — An ounce of white glass or enamel, half an ounce of good manganese; ground together.

Red, rose, and brown colours, are made from peroxide of iron, prepared by nitric acid. The flux consists of borax, sand, and minium in small quantity.

Red colour, may be likewise obtained from one ounce of red chalk pounded, mixed with two ounces of white hard enamel, and a little peroxide of copper.

A red, may also be composed of rust of iron, glass of antimony, yellow glass of lead, such as is used by potters (or litharge), each in equal quantity; to which a little sulphuret of silver is added. This composition, well ground, produces a very fine red colour on glass. When protoxide of copper is used to stain glass, it assumes a bright red or green colour, according as the glass is more or less heated in the furnace, the former corresponding to the orange protoxide, the latter having the copper in the state of peroxide.

Bistres and brown reds, may be obtained by mixtures of manganese, orange oxide of copper, and the oxide of iron called umber, in different proportions. They must be previously fused with vitreous solvents.

Green colour. — Two ounces of brass calcined into an oxide, two ounces of minium, and eight ounces of white sand; reduce them to a fine powder, which is to be enclosed in a well luted crucible, and heated strongly in an air-furnace for an hour. When the mixture is cold, grind it in a brass mortar. Green may, however, be advantageously produced by a yellow on one side, and a blue on the other. Oxide of chrome has been also employed to stain glass green.

A fine yellow colour. — Take fine silver laminated thin, dissolve in nitric acid, dilute with abundance of water, and precipitate with solution of sea salt. Mix this chloride of silver, in a dry powder, with three times its weight of pipe-clay well burnt and pounded. The back of the glass pane is to be painted with this powder, for when painted on the face, it is apt to run into the other colours.

Another yellow can be made by mixing sulphuret of silver with glass of antimony, and yellow ochre previously calcined to a red-brown tint. Work all these powders together, and paint on the back of the glass. Or silver *laminae* melted with sulphur, and glass of antimony, thrown into cold water, and afterwards ground to powder, afford a yellow.

A pale yellow may be made with the powder resulting from brass, sulphur, and glass of antimony, calcined together in a crucible, till they cease to smoke; and then mixed with a little burnt yellow ochre.

The fine yellow of M. Merand, is prepared from chloride of silver, oxide of zinc, white-clay, and rust of iron. This mixture, simply ground, is applied on the glass.

Orange colour. — Take 1 part of silver powder, as precipitated from the nitrate of that metal by plates of copper, and washed; mix it with 1 part of red ochre and 1 of yellow, by careful trituration; grind into a thin pap with oil of turpentine or lavender, and apply this with a brush, dry, and burn in.

In the *Philosophical Magazine*, of December, 1836, the anonymous author of an ingenious essay, "On the Art of Glass-painting," says, that if a large proportion of ochre has been employed with the silver, the stain is yellow; if a small proportion, it is orange-coloured; and by repeated exposure to the fire, without any additional colouring-matter, the orange may be converted into red: but this conversion requires a nice management of the heat. Artists often make use of panes coloured throughout their substance in the glass-house pots, because the perfect transparency of such glass gives a brilliancy of effect, which enamel painting, always more or less opaque, cannot rival. It was to a glass of this kind that the old glass-painters owed their splendid red. This is, in fact, the only point in which the modern and ancient processes differ; and this is the only part of the art which was ever really lost. Instead of blowing plates of solid red, the old glass-makers (like those of Bohemia, for some time back,) used to *flash* a thin layer of brilliant red over a substratum of colourless glass; by gathering a lump of the latter upon the end of their iron rod in one pot, covering with a layer of the former in another pot, then blowing out the two together into a globe

or cylinder, to be opened into circular tables, or into rectangular plates. The elegant art of tinging glass red by protoxide of copper, and flashing it on common crown glass, has become general within these few years.

That gold melted with flint glass stains it purple was originally discovered and practised, as a profitable secret, by Kunckel. Gold has been recently used at Birmingham for giving a beautiful rose-colour to scent bottles. The proportion of gold should be very small, and the heat very great, to produce a good effect. The glass must contain either the oxide of lead, bismuth, zinc, or antimony; for crown glass will take no colour from gold. Glass combined with this metal, when removed from the crucible, is generally of a pale rose-colour; nay, sometimes is as colourless as water, and does not assume its ruby colour till it has been exposed to a low red heat, either under a muffle or at the lamp. This operation must be nicely regulated; because a slight excess of fire destroys the colour, leaving the glass of a dingy brown, but with a blue (green?) transparency like that of gold leaf. It is metallic gold which gives the colour; and, indeed, the oxide is too easily reduced, not to be converted into the metal by the intense heat which is necessarily required.

Upon the kindred art of painting in enamel, Mr. A. Essex has published an interesting paper in the same journal, for June, 1837, in which he says that the ancient ruby glass, on being exposed to the heat of a glass-kiln, preserves its colour unimpaired, while the modern suffers considerable injury, and in some cases becomes almost black. Hence the latter cannot be painted upon, as the heat required to fix the fresh colour would destroy the beauty of the original basis. To obviate this difficulty, the artist paints upon a piece of plain glass the tints and shadows necessary for blending the rich ruby glow with the other parts of his picture, leaving those parts untouched where he wishes the ruby to appear in undiminished brilliancy, and fixes the ruby glass in the picture behind the painted piece, so that in such parts, the window is double-glazed. Mr. Essex employs, as did the late Mr. Muss, chrome oxide alone for greens; and he rejects the use of iron and manganese in his enamel colours.

Coloured transparent glass is applied as enamel in silver and gold *bijouterie*, previously *bright-cut* in the metal with the graver or the rose-engine. The cuts, reflecting the rays of light from their numerous surfaces, exhibit through the glass, richly stained with gold, silver, copper, cobalt, &c., a gorgeous play of prismatic colours, varied with every change of aspect. When the enamel is to be painted on, it should be made opalescent by oxide of arsenic, in order to produce the most agreeable effect.

The artist in enamel has obtained from modern chemistry preparations of the metals platinum, uranium, and chromium, which furnish four of the richest and most useful colours of his palette. Oxide of platinum produces a substantive rich brown, formerly unknown in enamel painting; a beautiful transparent tint, which no intensity or repetition of firing can injure. Colours proper for enamel painting, he says, are not to be purchased; those sold for the purpose, are adapted only for painting upon china. The constituents of the green enamel used by his brother, Mr. W. Essex, are, silica, borax, oxide of lead, and oxide of chrome.

Mr. Essex's enamelling furnace is a cubic space of about 12 inches, and contains a fire-clay muffle, without either bottom or back, which is surrounded with coke, except in front. The entire draught of air which supplies the furnace passes through the muffle; the plates and paintings being placed on a thin slab, made of tempered fire-clay, technically termed *planche*, which rests on the bed of coke-fuel. As the greatest heat is at the back of the muffle, the picture must be turned round while in the fire, by means of a pair of spring tongs. The above furnace serves for objects up to five inches in diameter; but for larger works a different furnace is required, for the description of which I must refer to the original paper.

Relatively to the receipts for enamel colours, and for staining and gilding on glass, for which twenty guineas were voted by the Society for the Encouragement of Arts, in the session of 1817, to Mr. R. Wynn, Mr. A. Essex says, in p. 446. of his essay—"the unfortunate artist who shall attempt to make colours for the purpose of painting in enamel from these receipts, will assuredly find, to his disappointment, that they are utterly useless." In page 449. he institutes a comparison between Mr. Wynn's complex farrago for green, as published in the Transactions of the Society, with the simple receipt of his brother, as given above. It is a remarkable circumstance, that not one of our enamel artists, during a period of twenty years, should have denounced the fallacy of these receipts, and the folly of sanctioning imposture by a public reward. Should Mr. Essex's animadversions be just, the well-intentioned Society in the Adelphi may, from the negligence of its committee, come to merit the *sobriquet*, "For the discouragement of Arts."

The blues of vitrified colours are all obtained from the oxide of cobalt. Cobalt ore (sulphuret) being well roasted at a dull red heat, to dissipate all the sulphur and arsenic, is dissolved in somewhat dilute nitric acid, and after the addition of much

water to the saturated solution, the oxide is precipitated by carbonate of soda, then washed upon a filter and dried. The powder is to be mixed with thrice its weight of saltpetre; the mixture is to be deflagrated in a crucible, by applying a red hot cinder to it, then exposed to the heat of ignition, washed and dried. Three parts of this oxide are to be mixed with a flux, consisting of white sand, borax, nitre and a little chalk, subjected to fusion for an hour, and then ground down into an enamel powder for use. Blues of any shade or intensity may be obtained from the above, by mixing it with more or less flux.

The beautiful greenish-yellow of which colour so many ornamental glass vessels have been lately imported from Germany, is made in Bohemia by the following process. Ore of uranium, Uran-ochre, or Uran-glimmer, in fine powder, being roasted and dissolved in nitric acid, the filtered solution is to be freed from any lead present in it by the cautious addition of dilute sulphuric acid. The clear green solution is to be evaporated to dryness, and the mass ignited till it becomes yellow. One part of this oxide is to be mixed with 3 or more parts of a flux, consisting of 4 parts of red lead and 1 of ground flint; the whole fused together and then reduced to powder.

Chrome Green. Triturate together in a mortar equal parts of chromate of potash and flowers of sulphur: put the mixture into a crucible and fuse. Pour out the fluid mass; when cool, grind and wash well with water to remove the sulphuret of potash and to leave the beautiful green oxide of chrome. This is to be collected upon a filter, dried, rubbed down along with thrice its weight of a flux, consisting of 4 parts of red lead and 1 part of ground flints fused into a transparent glass; the whole is now to be melted and afterwards reduced to a fine powder.

Violet. One part of calcined black oxide of manganese, one of zaffre, ten parts of white glass pounded, and one of red lead, mixed, fused, and ground. Or gold purple (Cassius's purple precipitate) with chlorsilver previously fused, with ten times its weight of a flux, consisting of ground quartz, borax, and red lead, all melted together; or solution of tin being dropped into a large quantity of water, solution of nitrate of silver may be first added, and then solution of gold in *aqua regia*, in proper proportions. The precipitate to be mixed with flux and fused.

Exhibition Stained Glass Windows.—Leaded work with medallions and ornamental work of the early Gothic style; and in the style of the fourteenth century, the figures being St. Peter and St. Paul, St. George and Britannia; armorial decoration; a landscape and ornamental work suitable for a dwelling house. Flowers painted and enamelled on a large plate of glass, with borders; the glass having been burnt in a kiln four times.

The interest attached to this beautiful art, and its comparatively recent revival, calls for a few remarks. Its antiquity is undoubted. Pliny speaks of "coloured glasses made to imitate precious stones and gems," and painted glass in the church of Nôtre Dame at Paris is described as early as the sixth century. To Sugerius Abbot of St. Denis, in 1150, is probably owing the reintroduction of painted glasses in churches. How rapidly his example was followed, is proved by the magnificent glass of the thirteenth century abounding on the continent, and partially existing in this country, the oldest examples we have being in Canterbury Cathedral. At first the ornaments consisted of a mere drapering; then rude representations of saints and kings; then panels of various forms, with subjects from the Testaments, on grounds of blue or ruby, the intermediate parts filled with Mosaic patterns in rich colours, and the whole enclosed within a coloured border. In later styles single figures predominated, with flowing patterns of foliage, and later still, with canopies over them. Some of the finest works are by French and Flemish artists; and this art was traditionally known to the early Florentine painter Cimabue, who is said to have introduced it into Italy. Probably our actual obligations are due to our Norman neighbours, as a necessary appendage to their architecture. It has been a popular notion that this art was lost to us; such is not the case; it has indeed been dormant, but never extinct.

STAMPING OF METALS. The following ingenious machine for manufacturing metal spoons, forks, and other articles, was made the subject of a patent by Jonathan Hayne, of Clerkenwell, in May, 1833. He employs a stamping-machine with dies, in which the hammer is raised to a height between guides, and is let fall by a trigger. He prefers fixing the protuberant or relief portion of the die to the stationary block or bed of the stamping-machine, and the counterpart or intaglio to the falling hammer or ram.

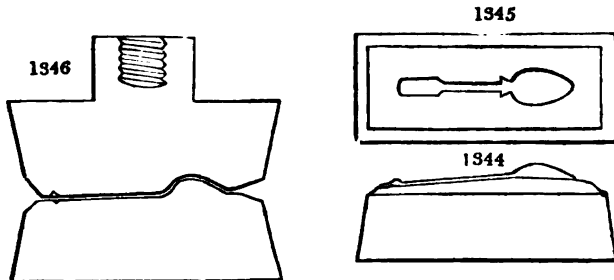
The peculiar feature of improvement in this manufacture consists in producing the spoon, ladle, or fork perfect at one blow in the stamping machine, and requiring no further manipulation of shaping, by simply trimming off the barb or fin, and polishing the surface to render the article perfect and finished.

Heretofore, in employing a stamping-machine, or fly-press, for manufacturing spoons, ladles, and forks, it has been the practice to give the impression to the handles, and to

the bowls or prongs, by distinct operations of different dies, and after having so partially produced the pattern upon the article, the handles had to be bent and formed by the operations of filing and hammering.

By his improved form of dies, which, having curved surfaces and bevelled edges, allow of no parts of the faces of the die and counter-die to come in contact, he is enabled to produce considerable elevations of pattern and form, and to bring up the article perfect at one blow, with only a slight barb or fin upon its edge.

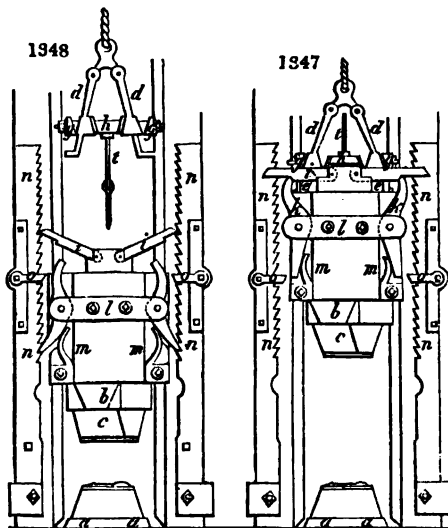
In the accompanying drawings, *fig.* 1344. is the lower or bed die for producing a



spoon, seen edgewise; *fig.* 1345. is the face of the upper or counter-die, corresponding; *fig.* 1346. is a section, taken through the middle of the pair of dies, showing the space in which the metal is pressed to form the spoon.

To manufacture spoons, ladles, or forks according to his improved process, he first forges out the ingot into flat pieces, of the shape and dimension of the die of the intended article; and if a spoon or ladle is to be made, gives a slight degree of concavity to the bowl part; but, if necessary, bends the back, in order that it may lie more steadily and bend more accurately, upon the lower die; if a fork, he cuts or otherwise removes portions of the metal at those parts which will intervene between the prongs; and, having thus produced the rude embryo of the intended article, scrapes its entire surface clean and free from oxidation-scale or fire-strain, when it is ready to be introduced into the stamping-machine.

He now fixes the lower die in the bed of the stamping-machine, shown at *a, a*, in the elevations *figs.* 1347. and 1348., and fixes, in the hammer *b*, the upper or counter-die *c*, accurately adjusting them both, so that they may correspond exactly when brought together. He then places the rudely-formed article above described upon the lower



die, and having drawn up the hammer to a sufficient elevation by a windlass and rope, or other ordinary means, lets go the trigger, and allows the hammer with the counter-die to fall upon the under die, on which the article is placed; when, by the blow thus given to the metal, the true and perfect figure and pattern of the spoon, ladle, or fork is produced, and which, as before said, will only require the removal of the slight edging of bard or fin, with polishing, to finish it.

On striking the blow, in the operation of stamping the article, the hammer will recoil and fly up some distance, and if allowed to fall again with reiterated blows, would injure both the article and the dies; therefore, to avoid this inconvenience, he causes the hammer on recoiling to be caught by a pair of palls locked into racks on the face of the standards, seen in *figs.* 1347. and 1348. In *fig*

1347. the hammer *b*, of the stamping-machine, is seen raised and suspended by a rope attached to a pair of jointed hooks or holders *d, d*, the lower ends of which pass into eyes *e, e*, extending from the top of the hammer. When the lever or trigger *t* is drawn forward, as in *fig. 1348.*, the two inclined planes *g, g*, on the axle *h*, press the two legs of the holders *d, d*, inward, and cause their hooks or lower ends to be withdrawn from the eyes *e, e*, when the hammer instantly falls, and brings the dies together : such is the ordinary construction of the stamping-machine.

On the hammer falling from a considerable elevation, the violence of the blow causes it to recoil and bound upwards, as before mentioned; it therefore becomes necessary to catch the hammer when it has rebounded, in order to prevent the dies coming again together; this is done by the following mechanism:—

Two latch levers *i, i*, are connected by joints to the upper part of the hammer, and two pall levers *k, k*, turning upon pins, are mounted in the bridge *l*, affixed to the hammer. Two springs *m, m*, act against the lower arms of these levers, and press them outwards, for the purpose of throwing the palls at the lower ends of the levers into the teeth of the ratchet racks, *n, n*, fixed on the sides of the upright standards.

Previously to raising the hammer, the upper ends of the pall levers *k*, are drawn back, and the latches *i*, being brought down upon them, as in *fig. 1347.*, the levers *k* are confined, and their palls prevented from striking into the slide racks; but as the hammer falls, the ends of the latches *i* strike upon the fingers *o, o*, fixed to the side standards, and liberate the palls, the lower ends of which, when the hammer rebounds, after stamping, catch into the teeth of the racks, as in *fig. 1378.*, and thereby prevent the hammer from again descending.

STANNATE OR STANNITE OF POTASH AND SODA. Stannates and stannites of alkalis are valuable mordants in calico printing, and are prepared by the patented plan of Messrs. Greenwood, Church and Barnes, as follows. For the stannate of soda : 22 pounds of caustic soda are first put into an iron crucible, heated to a low red heat, till the hydrate be produced; to which 8 pounds of nitrate of soda and 4 pounds of common salt are introduced. When the mixture is at a fluxing heat, 10 pounds of feathered block tin are added, and it is stirred with an iron rod. The mass now becomes dark coloured, and pasty, and ammonia is given off (the tin decomposing the water of the hydrated soda and part of the nitrate of soda.) The stirring is continued, as well as the heat, till deflagration takes place, and the mass becomes redhot, and pasty. This product is stannate of soda. It may be purified by solution and crystallization.

Stannite of soda is made by putting 4 pounds of common salt, 13½ pounds of caustic soda, and 4 pounds of feathered block tin into a hot iron crucible over a fire, and stirring and boiling to dryness, and as long as ammonia is given off. What remains is stannite of soda.

To produce the tin preparing liquor, 3 pounds of stannate of soda are dissolved in one gallon of boiling water, and 3 gallons or more of cold water, to bring it to the required strength. The stannite of soda is treated in the same way. The potash-stannate and stannite are prepared in like manner. These dilute liquors are thus prepared for the dyers and printers.

STARCH (*Amidon, Fecule, Fr.*; *Stärke, Germ.*); is a white pulverulent substance, composed of microscopic spheroids, which are bags containing the amylaceous matter. It exists in a great many different plants, and varies merely in the form and size of its microscopic particles: as found in some plants, it consists of spherical particles $\frac{1}{1000}$ of an inch in diameter; and in others of ovoid particles, $\frac{1}{300}$ or $\frac{1}{100}$ of an inch. It occurs, 1., in the seeds of all the scotyledonous plants, among which are the several species of corns, and those of other *gramineæ*; 2. in the round perennial tap roots, which shoot up an annual stem; in the tuberose roots, such as potatoes, the *Convolvulus batatas* and *edulis*, the *Helianthus tuberosus*, the *Jatropha manihot*, &c., which contain a great quantity of it; 3. in the stems of several monocotyledonous plants, especially of the palm tribe, whence sago comes; but it is very rarely found in the stems and branches of the dicotyledonous plants; 4. it occurs in many species of lichen. Three kinds of starch have been distinguished by chemists; that of wheat, that called *insuline*, and lichen starch. These three agree in being insoluble in cold water, alcohol, ether, and oils, and in being converted into sugar by either dilute sulphuric acid or diastase. The main difference between them consists in their habitudes with water and iodine. The first forms with hot water a mucilaginous solution, which constitutes, when cold, the paste of the laundress, and is tinged blue by iodine; the second forms a granular precipitate, when its solution in boiling-hot water is suffered to cool, which is tinged yellow by iodine; the third affords, by cooling, the concentrated solution, a gelatinous mass, with a clear liquid floating over it, that contains little starch. Its jelly becomes brown-gray with iodine.

1. *Ordinary starch.*—This may be extracted from the following grains:—wheat, rye,

barley, oats, buckwheat, rice, maize, millet, spelt; from the siliquose seeds, as peas, beans, lentiles, &c.; from tuberous and tap roots, as those of the potato, the orchis, manioc, arrow-root, batata, &c. Different kinds of corn yield very variable quantities of starch. Wheat differs in this respect, according to the varieties of the plant, as well as the soil, manure, season, and climate. See BRAD.

Wheat partly damaged by long keeping in granaries, may be employed for the manufacture of starch, as this constituent suffers less injury than the gluten; and it may be used either in the ground or unground state.

1. *With unground wheat.*—The wheat being sifted clean, is to be put into cisterns, covered with soft water, and left to steep till it becomes swollen and so soft as to be easily crushed between the fingers. It is now to be taken out, and immersed in clear water of a temperature equal to that of malting-barley, whence it is to be transferred into bags, which are placed in a wooden chest containing some water, and exposed to strong pressure. The water rendered milky by the starch being drawn off by a tap, fresh water is poured in, and the pressure is repeated. Instead of putting the swollen grain into bags, some prefer to grind it under vertical edge-stones, or between a pair of horizontal rollers, and then to lay it in a cistern, and separate the starchy liquor by elutriation with successive quantities of water well stirred up with it. The residuary matter in the sacks or cisterns contained much vegetable albumen and gluten, along with the husks; when exposed to fermentation, it affords a small quantity of starch of rather inferior quality.

The above milky liquor, obtained by expression or elutriation, is run into large cisterns, where it deposits its starch in layers successively less and less dense; the uppermost containing a considerable proportion of gluten. The supernatant liquor being drawn off, and fresh water poured on it, the whole must be well stirred up, allowed again to settle, and the surface-liquor again withdrawn. This washing should be repeated as long as the water takes any perceptible colour. As the first turbid liquor contains a mixture of gluten, sugar, gum, albumen, &c., it ferments readily, and produces a certain portion of vinegar, which helps to dissolve out the rest of the mingled gluten, and thus to bleach the starch. It is, in fact, by the action of this fermented or soured water, and repeated washing, that it is purified. After the last deposition and decantation, there appears on the surface of the starch a thin layer of a slimy mixture of gluten and albumen, which being scraped off, serves for feeding pigs or oxen; underneath will be found a starch of good quality. The layers of different sorts are then taken up with a wooden shovel, transferred into separate cisterns, where they are agitated with water, and passed through fine sieves. After this pap is once more well settled, the clear water is drawn off, the starchy mass is taken out, and laid on linen cloths in wicker baskets, to drain and become partially dry. When sufficiently firm, it is cut into pieces which are spread upon other cloths, and thoroughly desiccated in a proper drying-room, which in winter is heated by stoves. The upper surface of the starch is generally scraped, to remove any dusty matter, and the resulting powder is sold in that state. Wheat yields, upon an average, only from 35 to 40 per cent. of good starch. It should afford more by skilful management.

2. In this country, wheat crushed between iron rollers is laid to steep in as much water as will wet it thoroughly; in four or five days the mixture ferments, soon afterwards settles, and is ready to be washed out with a quantity of water into the proper fermenting vats. The common time allowed for the steep is from 14 to 20 days. The next process consists in removing the stuff from the vats into a stout round basket set across a back below a pump. One or two men keep going round the basket, stirring up the stuff with strong wooden shovels, while another keeps pumping water, till all the *farina* is completely washed from the bran. Whenever the subjacent back is filled, the liquor is taken out and strained through hair sieves into square frames or cisterns, where it is allowed to settle for 24 hours; after which the water is run off from the deposited starch by plug traps at different levels in the side. The thin stuff, called *slimes*, upon the surface of the starch, is removed by a tray of a peculiar form. Fresh water is now introduced, and the whole being well mixed by proper agitation, is then poured upon fine silk sieves. What passed through is allowed to settle for 24 hours; the liquor being withdrawn, and then the slimes, as before, more water is again poured in, with agitation, when the mixture is again thrown upon the silk sieve. The milky liquor is now suffered to rest for several days, 4 or 5, till the starch becomes settled pretty firmly at the bottom of the square cistern. If the starch is to have the blue tint, called Poland, fine smalt must be mixed in the liquor of the last sieve, in the proportion of 2 or 3 lbs. to the cwt. A considerable portion of these slimes may, by good management, be worked up into starch by elutriation and straining.

The starch is now fit for *bozing*, by shovelling the cleaned deposit into wooden chests, about 4 feet long, 12 inches broad, and 6 inches deep, perforated throughout, and lined

with thin canvas. When it is drained and dried into a compact mass, it is turned out by inverting the chest upon a clean table, where it is broken into pieces 4 or 5 inches square, by laying a ruler underneath the cake, and giving its surface a cut with a knife, after which the slightest pressure with the hand will make the fracture. These pieces are set upon half-burned bricks, which by their porous capillarity imbibe the moisture of the starch, so that its under surface may not become hard and horny. When sufficiently dried upon the bricks, it is put into a stove (which resembles that of a sugar refinery), and left there till tolerably dry. It is now removed to a table, when all the sides are carefully scraped with a knife; it is next packed up in the papers in which it is sold; these packages are returned into the stove, and subjected to a gentle heat during some days; a point which requires to be skilfully regulated.

Mr. Samuel Hall obtained a patent for bleaching starch by chloride of lime in 1821. Chlorine water would probably be preferable, and might prove useful in operating upon damaged wheat.

The sour water of the starch manufacture contains, according to Vauquelin, acetic acid, acetate of ammonia, alcohol, phosphate of lime, and gluten.

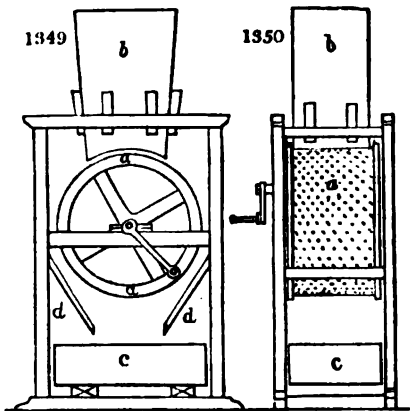
During the drying, starch splits into small prismatic columns, of considerable regularity. When kept dry, it remains unaltered for a very long period. When it is heated to a certain degree in water, the envelopes of its spheroidal particles burst, and the *farina* forms a mucilaginous emulsion, magma, or paste. When this apparent solution is evaporated to dryness, a brittle horny-looking substance is obtained, quite different in aspect from starch, but similar in chemical habitudes. When the moist paste is exposed for 2 or 3 months to the air in summer, the starch is converted into sugar, to the amount of one-third or one-half of its weight, into gum, and gelatinous starch called *amidine* by De Saussure, with occasionally a resinous matter. This curious change goes on even in close vessels.

Starch from potatoes. — From the following table of analyses, it appears that potatoes contain from 24 to 30 per cent. of dry substance: —

| | Starch. | Fibrous parenchyma. | Veg. Albumen. | Gum, Sugar, and Salts. | Water. |
|-----------------------|---------|---------------------|---------------|------------------------|--------|
| Red potato - - | 15.0 | 7.0 | 1.4 | 9.2 | 75.0 |
| Germinating potatoes | 15.0 | 6.8 | 1.3 | 5.7 | 73.0 |
| Kidney potatoes | 9.1 | 8.8 | 0.8 | — | 81.3 |
| Large red potatoes - | 12.9 | 6.0 | 0.7 | — | 78.0 |
| Sweet potatoes - - | 15.1 | 8.2 | 0.8 | — | 74.3 |
| Peruvian potatoes | 15.0 | 5.2 | 1.9 | 1.9 | 76.0 |
| English potatoes - - | 12.9 | 6.8 | 1.1 | 1.7 | 77.5 |
| Parisian potatoes - - | 13.3 | 6.8 | 0.9 | 4.8 | 73.1 |

Manufacture of potato starch. — The potatoes are first washed in a cylindrical cage formed of wooden spars, made to revolve upon a horizontal axis, in a trough filled with water to the level of the axis. They are then reduced to a pulp by a rasping machine, similar to that represented in *Figs. 1349, 1350.*, where *a* is a wooden drum covered with sheet-iron, roughened outside with numerous prominences, made by punching out holes from the opposite side. It is turned by a winch fixed upon each end of the shaft. The drum is enclosed in a square wooden box, to prevent the potato-mash from being scattered about. The hopper *b* is attached to the upper frame, has its bottom concentric with the rasp-drum, and nearly in contact with it. The pulp chest *c* is made to slide out, so as when full to be readily replaced by another. The two slanting boards *d, d*, conduct the pulp into it. A moderate stream of water should be made to play into the hopper upon the potatoes, to prevent the surface of the rasp from getting foul with fibrous matter. Two men, with one for a relay, will rasp, with such a machine, from 2½ to 3 tons of potatoes in 12 hours.

The potato pulp must be now elutriated upon a fine wire or hair sieve, which is set upon a frame in the mouth of a large vat, while water is made to flow upon it from a spout with many jets. The pulp meanwhile must be stirred and kneaded by the hand, or by a mechanical brush-agitator, till almost nothing but fibrous particles are left upon the sieve. These, however, generally retain about 5 per cent. of starch, which cannot be separated in this way. This parenchyma should therefore be subjected to a separate rasping upon another cylinder. The water, turbid with starch, is allowed to settle for some time in a back; the supernatant liquor is then run by a cock into a second back, and after some time into a third, whereby the whole starch will be precipitated. The finest



powder collects in the last vessel. The starch thus obtained, containing 33 per cent. of water, may be used either in the moist state, under the name of *grœs fecula*, for various purposes, as for the preparation of dextrine and starch syrup, or it may be preserved under a thin layer of water, which must be renewed from time to time, to prevent fermentation; or lastly, it may be taken out and dried.

In trials made with St. Etienne's rasp and starch machinery, in Paris, which was driven by two horses, nearly 18 cwt. of potatoes were put through all the requisite operations in one hour, including the pumping of the water. The product in starch amounted to from 17 to 18 per cent. of the potatoes. The quicker the process of potato-starch making, the better is its quality.

Starch from certain foreign plants. — 1. From the pith of the *sago palm*. See SAGO.

2. From the roots of the *Maranta arundinacea*, of Jamaica, the Bahamas, and other West India islands, the powder called arrow-root is obtained, by a process analogous to that for making potato starch.

3. From the root of the *Manioc*, which also grows in the West Indies, as well as in Africa, the *cassava* is procured, by a similar process. The juice of this plant is poisonous, from which the wholesome starch is deposited. When dried with stirring upon hot iron plates, it agglomerates into small lumps, called *tapioca*; being a gummy fecula.

The characters of the different varieties of starch can be learnt only from microscopic observation; by which means also their sophistication or admixture may be readily ascertained.

Starch, from whatever source obtained, is a white soft powder, which feels crispy, like flowers of sulphur, when pressed between the fingers; it is destitute of taste and smell, unchangeable in the atmosphere, and has a specific gravity of 1.53. I have already described the particles as spheroids enclosed in a membrane. The potato contains some of the largest, and the millet the smallest. Potato starch consists of truncated ovoids varying in size from $\frac{1}{100}$ to $\frac{1}{300}$ of an inch; arrow-root, of ovoids varying in size from $\frac{1}{100}$ to $\frac{1}{1000}$ of an inch; flour starch, of insulated globules about $\frac{1}{100}$ of an inch; cassava, of similar globules assembled in groups. These measurements I have made with a good achromatic microscope, and a divided glass-slip micrometer of Tully.

For the saccharine changes which starch undergoes by the action of *diastase*, see FERMENTATION.

Lichenine, a species of starch obtained from Iceland moss (*Cetraria islandica*, as well as *inuline*, from elecampane (*Inula helenium*), are rather objects of chemical curiosity than of manufactures.

There is a kind of starch made in order to be converted into gum for the calico-printer. This conversion having been first made upon the great scale in this country, has occasioned the product to be called British gum. The following is the process pursued in a large and well conducted establishment near Manchester. A range of four wooden cisterns, each about 7 or 8 feet square, and 4 feet deep, is provided. Into each of them 2000 gallons of water being introduced, 12½ loads of flour are stirred in. This mixture is set to ferment upon old leaven left at the bottom of the backs, during 2 or 3 days. The contents are then stirred up, and pumped off into 3 stone cisterns, 7 feet square and 4 feet deep; as much water being added, with agitation, as will fill the cisterns to the brim. In the course of 24 hours the starch forms a firm deposit at the bottom; and the water is then syphoned off. The gluten is next scraped from the surface, and the starch is transferred into wooden boxes pierced with holes, which may be lined with coarse cloth, or not, at the pleasure of the operator.

The starch, cut into cubical masses, is put into iron trays, and set to dry in a large apartment, two stories high, heated by a horizontal cylinder of cast-iron traversed by the flame of a furnace. The drying occupies two days. It is now ready for conversion into gum, for which purpose it is put into oblong trays of sheet iron, and heated to the temperature of 300° F. in a cast-iron oven, which holds four of these trays. Here it concretes into irregular semi-transparent yellow-brown lumps, which are ground into fine flour between mill stones, and in this state brought to the market. In this roasted starch, the vesicles being burst, their contents become soluble in cold water. British

gum is not convertible into sugar, as starch is, by the action of dilute sulphuric acid; nor into mucic acid, by nitric acid; but into the oxalic; and it is tinged purple-red by iodine. It is composed, in 100 parts, of 35.7 carbon, 6.2 hydrogen, and 58.1 oxygen; while starch is composed of, 48.5 carbon, 6.8 hydrogen, and 49.7 oxygen.

To prove whether starch be quite free from gluten, or whether it be mixed with any wheat flour, diffuse 12 grains of it through six ounces of water, heat the mixture to boiling, stirring it meanwhile with a glass slip. If the starch be pure, no froth will be seen upon the surface of the pasty fluid; or if any be produced during the stirring, it will immediately subside after it; but if the smallest portion of gluten be present, much froth will be permanently formed, which may be raised by stirring into the appearance of soap suds.

Starch has been made the subject of a patent by Mr. Thomas Berger, of Hackney, under which he soaks rice in caustic alkali, as Mr. Wickham did in 1824, at successive times, levigates it into a cream, adds one part of oil of turpentine to 2000 gallons of the cold mash, stirs the mixture, filters or strains through fine lawn sieves, settles, neutralizes with dilute sulphuric acid, and adding 8 oz. of sulphate of zinc to each cwt. of starch, stirs, boxes, and finishes as usual. One is apt to ask what purpose the spirits of turpentine can serve in such a small quantity, except it be to prevent fermentation. He also suggests electricity; but how to use it he says not.

In June, 1841, Mr. W. T. Berger obtained a patent for manufacturing starch by the agency of an alkaline salt upon rice. He prefers the carbonates of potash and soda.

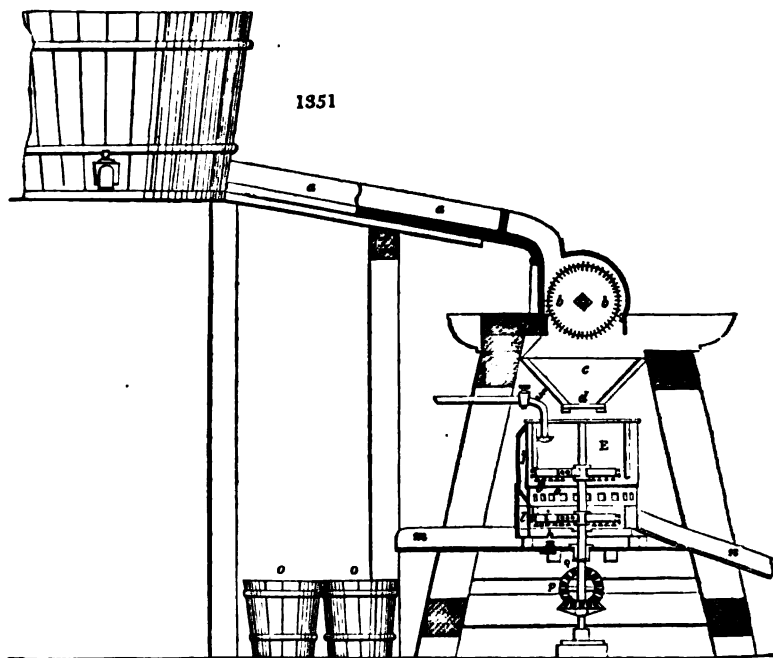
In January, 1839, M. Pierre Isidore Verdure obtained a patent for making starch, the chief object of which was to obtain the gluten of the wheat in a pure state, as a suitable ingredient in making bread, biscuits, &c. He works wheat flour into dough by a machine, kneads it, washes out the starch by streams of cold water, a process long known to the chemist, and purifies the starch by fermentation of the superjacent water. I can see nothing new in his specification.

Mr. Jones's patent, of date April, 1840, is based upon the purification of the starch of rice and other farinaceous matters by means of caustic alkali. He macerates 100 lbs. of ground rice in 100 gallons of a solution composed of 200 grains of caustic soda or potash to a gallon of water, stirs it gradually till the whole be well mixed; after 24 hours draws off the superjacent liquid solution of gluten in alkali, treats the starchy deposit with a fresh quantity of weak caustic lye, and thus repeatedly, till the starch becomes white and pure. The rice before being ground is steeped for some time in a like caustic lye, drained, dried, and sent to the mill.

Starch is made from wheat flour in a like way. The gluten may be recovered for use by saturating the alkaline solution with sulphuric acid, washing and drying the precipitate.

Mr. James Colman, by his patent invention of December, 1841, makes starch from ground maize or Indian corn, by the agency either of the ordinary process of steeping and fermenting, or of caustic or carbonated alkaline lyes. He also proposes to employ dilute muriatic acid to purify the starchy matter from gluten, &c. — See *Newton's Journal*, C. S. xix. 246.; xx. 184. 188.; and xxi. 175.

The manufacture of potato flour (*fecule*) or starch in France and Holland has been economised to such a degree that they supply this country with it, at the rate of 8s. or 10s. a hundredweight. Fig. 1351. represents in section the powerful and ingenious mechanical grater, or rasp (*rape*) now used in France. *aa*, is the canal, or spout, along which the previously well-washed potatoes descend; *bb*, is the grater, composed of a wooden cylinder, on whose round surface circular saw rings of steel, with short sharp teeth, are planted pretty close together. The greater the velocity of the cylinder, the finer is the pulp. A cylinder 20 inches in diameter revolves at the rate of from 600 to 900 times in a minute, and it will convert into pulp from 14 to 15 hectolitres (about 300 imperial gallons) of potatoes in an hour. Potatoes contain from 15 to 22 per cent. of dry fecula. The pulp, after leaving the rasp, passes directly into the apparatus for the preparation of the starch. *cc*, is a wooden hopper for receiving the falling pulp, with a trap door, *d*, at bottom. *e*, is the cylinder-sieve of M. Etienne; *f*, a pipe ending in a rose spout, which delivers the water requisite for washing the pulp, and extracting the starch from it; *g g*, a diaphragm of wire cloth, with small meshes, on which the pulp is exposed to the action of the brushes *i i*, moving with great speed, whereby it gives out its starchy matter, which is thrown out by a side aperture into the spout *n*. The fecula now falls upon a second web of fine wire-cloth, and leaves upon it merely some fragments of the parenchyma or cellular matter of the potato, to be turned out by a side opening in the spout *n*. The sifting or straining of the starch likewise takes place through the sides of the cylinder, which consist also of wire-cloth; it is collected into a wooden spout, *m*, and is thence conducted into the tubes *oo*, to be deposited and washed. *p*, is a mitre-toothed wheel-work placed on the driving-shaft, and gives motion to the upright axis or spindle, *q q*, which turns the brushes, *i i*.



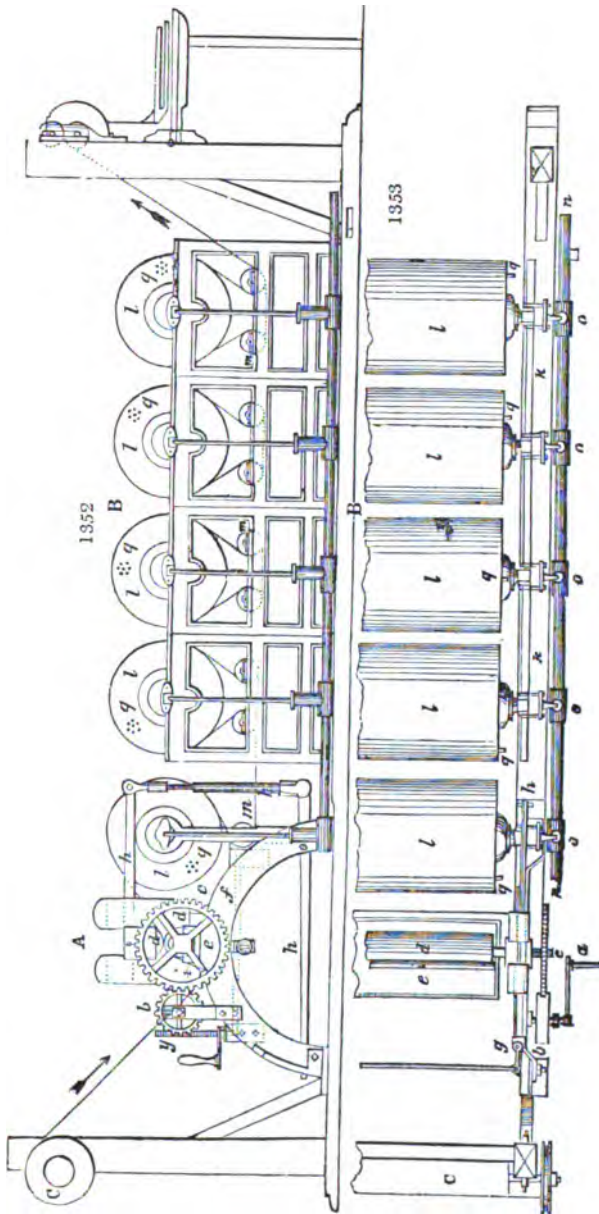
Starch prepared from rice or maize by alkali is said not to require boiling—a point of great importance in its use; and, being less hygrometric than wheat starch, retains a more permanent stiffness and glaze. The rough starch obtained in the process is valuable for feeding purposes, and for stiffening coarse fabrics.

STARCHING AND STEAM-DRYING APPARATUS. The system of hollow cylinders, for drying goods in the processes of bleaching or calico-printing, is represented in *fig. 1352*, in a longitudinal section, and in *fig. 1353*, in a top view; but the cylinders are supposed to be broken off in the middle, as it was needless to repeat the parts at the other end, which are sufficiently shown in the section.

a is the box containing the paste, when the goods are to be starched or stiffened; *a*, a winch, when it is desired to turn the machine by hand, though it is always moved by power in considerable factories; *b*, is the driving pinion; *d, d'*, two brass rollers with iron shafts, the undermost of which is moved by the wheel *c*, in gear with the pinion *b*. The uppermost roller *d'*, is turned by the friction with the former, *d*, being pressed upon it by the weighted lever *h*; *e* is the trough filled with the paste, which rests upon the bars *f*, and may be placed higher or lower by means of the adjusting screws *g*, according as the roller *d* is to be plunged more or less deeply. A brass roller *i* serves to force down the cloth into the paste.

b, is the drying part of the machine: *k, k*, its iron framing; *l, l, &c.*, five drums, or hollow copper cylinders, heated with steam: *m, m, m, &c.*, small copper drums, in pairs, turning freely on shafts under the former, for stretching the goods, and airing them, during their passage through the machine: *n, n*, is the main steam-pipe, from which branch off small copper tubes, *o, o, &c.*, which conduct the steam through stuffing-boxes into the cavity of the drying-drums. There are similar tubes upon the other ends of the drums, for discharging the condensed water through similar stuffing-boxes: *g, g*, are valves, opening internally, for admitting the air whenever the steam is taken off, or becomes feeble, to prevent the drums from being crushed by the unbalanced pressure of the atmosphere upon their external surfaces.

c, is the cloth-beam, from which the starching roller draws forwards the goods; *n*, are two rollers, of which the lower is provided with a band-pulley or rigger, driven by a similar pulley fixed upon the shaft of the starching roller *d*. These two rollers pull the goods through the drying machine, and then let them fall either upon a table or the floor.



STATUARY, cast in zinc, bronzed; and in other metals.—This is a new branch of art lately sprung up in Birmingham, which displays equal constructive economy and taste. Bronze varies in its composition, according to the taste of the artist, as to its hardness or the depth of its colour. A very excellent bronze is formed by the addition of 2 oz. of tin to 16 of copper.

The casting of a bronze statue may be thus described. The core is made up of brick-work and clay until a rude representation of the intended work is made; upon this the

sculptor models in wax, of the thickness intended for the metal, all the details, such as the features, drapery, &c.; when this is completed, it is coated with loam of very thin consistency; then follow repeated solid coatings of clay, &c., until a shell of sufficient strength to bear the pressure of the melted metal is formed; the whole is then bound together, best is applied, the wax is melted out, and a space thereby left for the introduction of the metal; suitable runners are made and vents to allow of the free escape of air. The metal is melted in reverberating furnaces, and when in a proper condition, the plug is withdrawn, and the mould filled. After being allowed to remain till cool it is opened, the roughness cleansed off, and the statue is completed. The peculiar tinge of the bronze is acquired by exposure to the air.

A bronze of nearly the same tinge is given to brass by immersion in a mixture of spirits of salt and arsenic; the metal is to be heated previous to this; the article is afterwards brushed with black-lead, and after being again heated, is coated with a lacquer, composed of spirits of wine, with a little yellow colouring matter; the shade of antiquity is thus imparted in a few minutes.

The establishment of Messrs. Messenger and Son is one of the oldest in the trade in Birmingham; it has been in existence upwards of 50 years: it was one of the earliest to recognise the importance of the union of art with manufactures. For this the genius of Flaxman and Chantrey was called into requisition; artists celebrated for their skill in architectural enrichment were also employed in the modelling of balustrades, candelabra, tripods, &c.

STEAM, is the vapour of hot water; the discussion of which belongs to chemistry, physics, and engineering. Certain practical applications of the subject will be found in the article EVAPORATION.

Steam; its laws. An able memoir on the pressure and density of steam was laid before the Institute of Civil Engineers in June, 1843, by Mr. Pole, C. E., which deserves confidence for its accuracy and usefulness. He proposed a new formula for the relation between these two mechanical quantities, applicable particularly to engines working with high pressure steam expansively.

The relations between the elasticity, temperature, and density of steam have long been interesting and important subjects of philosophical research. They are fully discussed, and represented in extensive tables in *Prestch's Technological Encyclopædia*, article *Dämpfe*.

The connexion of the two former, namely, pressure and temperature, with each other, has excited the greatest attention, numerous experiments having been undertaken to ascertain the values of them at all points of the scale, and many formulæ proposed by English and foreign mathematicians, to express approximately the relation between them.

The pressure and temperature being known, the density, or what answers the same purpose, the relative volume, compared with the water which has produced it, may be deduced by a combination of the laws of Boyle and Gay Lussac, and may be expressed algebraically in terms of the pressure and temperature combined; whence, by eliminating the latter, by means of the before mentioned formulæ, expressions can be arrived at which will connect at once the volume with the pressure.

But there are several difficulties in the way of this process, the equations which may be thus obtained being too complicated for practical use; and therefore, since it is important in calculations connected with steam and the steam engine, to find a tolerably accurate, and at the same time simple rule, which shall give the pressure and volume directly in terms of each other, the empirical method has been resorted to.

The paper enumerates three formulæ given for this purpose by M. Navier and M. de Pambour, explaining the peculiar cases to which they are applicable, and those in which they fail; and the author then proposes a fourth expression, which is intended to meet a case not provided for by either of the others, namely, for "condensing engines working with high pressure steam expansively;" such as the Cornish and Woult's double cylinder engine. The equation is,

$$P = \frac{24250}{V-65}$$

$$\text{or reciprocally, } V = \frac{24250}{P} + 65$$

P being the total pressure of the steam in lbs. per square inch, and V its relative volume, compared with that of its constituent water.

These formulæ may be adopted without considerable error throughout the range generally required in such engines, viz., from about 5 lbs. to 65 lbs. per square inch.

Two tables are then given, showing the pressure and volumes, as calculated for every

5 lbs. pressure in this scale; they show a comparison of the results of the four formulæ with each other, and the respective amount of deviation from truth in each.

The greatest error is,—

| | lbs. |
|-----------------------------------|-----------------------|
| By M. Navier's formula - - - | 1.31 per square inch. |
| M. de Pambour's first ditto - - - | 4.12 " |
| " " second ditto - - - | 2.75 " |
| The new formula - - - | 0.71 " |

The mean error is, —

| | |
|-----------------------------------|------------------------|
| By M. Navier's formula - - - | 0.245 per square inch. |
| M. de Pambour's first ditto - - - | 1.42 " |
| " " second ditto - - - | 0.35 " |
| The new formula - - - | 0.0062 " |

The tables also show : —

1. That the new formula is nearer the truth than either of the others, taken separately, in three-fourths of the scale.

2. That it is nearer than all three combined in half the scale.

3. That the greatest error of the new formula, with regard to the pressures, is only about half as great as that of the most correct of the other three.

4. That the mean error is only one-fortieth of either of the others, and equal to only about one-tenth of an ounce per square inch.

5. That the errors in the volumes are much less numerous and important with the new formula than with either of the others.

6. It is also added, that the new expression is simpler in algebraical form than the others; it is more easily calculated, the constants are easier to remember, and that no alteration of the constants in the other formulæ will make them coincide so nearly with the truth as the new one does.

Steam, (spherical state of). It is a well known fact, that if a small quantity of water be thrown on to a metallic plate, heated to a temperature approaching dull redness, the water is not, as might have been expected, rapidly dissipated in vapour, but, assuming a somewhat globular form, it remains quiescent, or slightly agitated only by the action of the heat, sometimes rolling over the surface of the heated plate. It is evident, in this case, that the water is not in contact with the metal; consequently there is no adhesion. Very little evaporation takes place from the water when in this, which has been called the spherical, condition. Although in close proximity to a plate of, it might be, red hot metal, the water appears to be heated only to about 205°, and in this condition it remains, undergoing slow evaporation, until the metal becomes so far cooled as to admit of the water coming into contact with it; when this occurs, the water loses its spherical condition, flows over the surface of the still highly heated metal, with which it now is in contact, and it is instantly dissipated in vapour.

A great number of interesting experiments have been made in connection with this subject by M. Boutigny, and on the results have been founded an explanation of that class of boiler explosions which occur *after*, but not *at the moment of*, the excessive heating of the boiler. It is assumed that in these cases the boiler becomes heated to a temperature at which the water is thrown into the spherical condition; while in this state very little steam is generated, but as soon as the boiler has cooled to a point at which contact takes place, the sudden formation of a large volume of steam causes the explosion.

It has been found that other volatile bodies besides water are similarly affected under like circumstances. Thus, ether, alcohol, iodine, &c. assume the spherical condition when thrown into a metallic vessel (a platinum crucible for instance) heated to redness. The vaporization of these bodies under such circumstances is comparatively slow, but when the vessel has cooled to the point of contact, there is an immediate augmentation of vapour. This forms a pretty experiment with iodine, the period of contact being indicated by the increased volume of its violet coloured vapour. M. Boutigny, availing himself of the fact that even the most volatile bodies are capable of assuming this spherical condition, has devised a method of freezing water in a red hot crucible. This experiment is performed in the following manner:—Some liquid anhydrous sulphurous acid is first prepared, by passing the dry gas through a tube surrounded with a freezing mixture of ice and salt, and collecting the product in a small tube sealed at one end, also surrounded with a freezing mixture. This liquefied sulphurous acid boils at 14° Fahr., and therefore, if it is to be kept for any length of time, the mouth of the tube must be sealed at the blowpipe flame. A thick platinum crucible having a capacity of about f3j is to be heated to redness, and while in this state, about f3j of the sulphurous acid is to be rapidly projected out of the tube into

the crucible. The acid assumes the spherical condition, and while in this state undergoes comparatively slow evaporation; the lamp is now quickly withdrawn, and a small quantity of water thrown into the crucible with a syringe. The temperature of the crucible is reduced by the introduction of the water, so as to cause the contact, and consequently the instantaneous vaporization, of the sulphurous acid, which during its vaporization, robs the water of its heat and reduces it to the state of ice.

STEARIC ACID, improperly called *STEARINE* (*Talgaeure*, Germ.), is the solid constituent of fatty substances, as of tallow and olive oil, converted into a crystalline mass by saponification with alkaline matter, and abstraction of the alkali by an acid. By this process, fats are convertible into three acids, called Stearic, Margaric, and Oleic; the first two being solid, and the last liquid. The stearine, of which *factitious* wax candles are made, consists of the stearic and margaric acids combined. These can be separated from each other only by the agency of alcohol, which holds the margaric acid in solution after it has deposited the stearic in crystals. Pure stearic acid is prepared, according to its discoverer, Chevreul, in the following way:— Make a soap, by boiling a solution of potash and mutton-suet in the proper equivalent proportions (see *Soap*); dissolve one part of that soap in 6 parts of hot water, then add to the solution 40 or 50 parts of cold water, and set the whole into a place whose temperature is about 52° Fahrenheit. A substance falls to the bottom, possessed of pearly lustre, consisting of the bi-stearate and bi-margarate of potash; which is to be drained and washed upon a filter. The filtered liquor is to be evaporated, and mixed with the small quantity of acid necessary to saturate the alkali left free by the precipitation of the above bi-salts. On adding water to it afterwards, the liquor affords a fresh quantity of bi-stearate and bi-margarate. By repeating this operation with precaution, we finally arrive at a point when the solution contains no more of these solid acids, but only the oleic. The precipitated bi-salts are to be washed and dissolved in hot alcohol, of specific gravity 0·820, of which they require about 24 times their weight. During the cooling of the solution, the bi-stearate falls down, while the greater part of the bi-margarate, and the remainder of the oleate, remain dissolved. By once more dissolving in alcohol, and crystallizing, the bi-stearate will be obtained alone; as may be proved by decomposing a little of it in water at a boiling heat, with muriatic acid, letting it cool, washing the stearic acid obtained, and exposing it to heat, when, if pure, it will not fuse in water under the 158th degree of Fahrenheit's scale. If it melts at a lower heat, it contains more or less margaric acid. The purified bi-stearate being decomposed by boiling in water along with any acid, as the muriatic, the disengaged stearic acid is to be washed by melting in water, then cooled and dried.

Stearic acid, prepared by the above process, contains combined water, from which it cannot be freed. It is insipid and inodorous. After being melted by heat, it solidifies at the temperature of 158° Fahrenheit, and affects the form of white brilliant needles grouped together. It is insoluble in water, but dissolves in all proportions in boiling anhydrous alcohol, and on cooling to 122°, crystallizes therefrom in pearly plates: but if the concentrated solution be quickly cooled to 112°, it forms a crystalline mass. A dilute solution affords the acid crystallized in large white brilliant scales. It dissolves in its own weight of boiling ether of 0·727, and crystallizes on cooling in beautiful scales, of changing colours. It distils over *in vacuo* without alteration; but if the retort contains a little atmospheric air, a small portion of the acid is decomposed during the distillation; while the greater part passes over unchanged, but slightly tinged brown, and mixed with traces of empyreumatic oil. When heated in the open air, and kindled, stearic acid burns like wax. It contains 3·4 per cent. of water, from which it may be freed by combining it with oxide of lead. When this anhydrous acid is subjected to ultimate analysis, it is found to consist of—80 of carbon, 12·5 hydrogen, and 7·5 oxygen, in 100 parts. Stearic acid displaces, at a boiling heat in water, carbonic acid from its combinations with the bases; but in operating upon an alkaline carbonate, a portion of the stearic acid is dissolved in the liquor before the carbonic acid is expelled. This decomposition is founded upon the principle, that the stearic acid transforms the salt into a bicarbonate, which is decomposed by the ebullition.

Stearic acid put into a strong watery infusion of litmus has no action upon it in the cold; but when hot, the acid combines with the alkali of the litmus, and changes its blue colour to red; so that it has sufficient energy to abstract from the concentrated tincture all the alkali required for its neutralization. If we dissolve bi-stearate of potash in weak alcohol, and pour litmus water, drop by drop, into the solution, this will become red, because the litmus will give up its alkali to a portion of the bi-stearate, and will convert it into neutral stearate. If we now add cold water, the reddened mixture will resume its blue tint, and will deposit bi-stearate of potash in small spangles. In order that the alcoholic solution of the bi-stearate may redden the litmus, the alcohol should not be very strong.

From the composition of stearate of potash, the atomic weight of the acid appears to be 106.6; hydrogen being 1; for $18 : 48 \times 2 : 100 : 533.3 = 5$ atoms of acid.

From the stearate of soda, it appears to be 104; and from that of lime, 102. The stearate of lead, by Chevreul, gives 109 for the atomic weight of the acid.

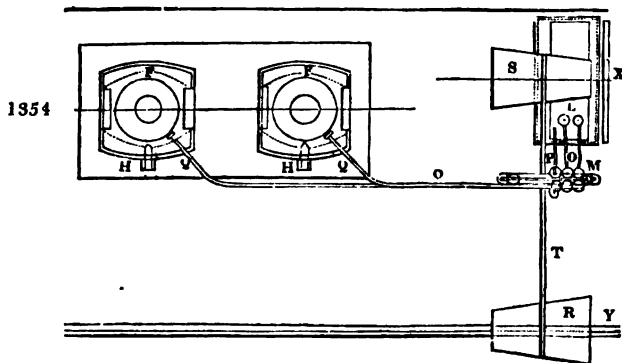
The margaric and oleic acids seem to have the same neutralising power, and the same atomic weight.

The preceding numbers will serve to regulate the manufacture of stearic acid for the purpose of making candles. Potash and soda were first prescribed for saponifying fat, as may be seen in M. Gay Lussac's patent, under the article CANDLE; and were it not for the cost of these articles, they are undoubtedly preferable to all others in a chemical point of view. Of late years lime has been had recourse to, with perfect success, and has become subservient to a great improvement in candle-making. The stearine block now made by many London houses, though containing not more than 2 or 3 per cent. of wax, is hardly to be distinguished from the purified produce of the bee. The first process is to boil the fat with quicklime and water in a large tub by means of perforated steam pipes distributed over its bottom. From the above statement we see that about 11 parts of dry lime are fully equivalent to 100 of stearine and oleine mixed; but as the lime is in the state of hydrate, 14 parts of it will be required when it is perfectly pure; in the ordinary state, however, as made from average good limestone, 16 parts may be allowed. After a vigorous ebullition of 3 or 4 hours, the combination is pretty complete. The stearate being allowed to cool to such a degree as to allow of its being handled, becomes a concrete mass, which must be dug out with a spade, and transferred into a contiguous tub, in order to be decomposed with the equivalent quantity of sulphuric acid diluted with water, and also heated with steam. Four parts of concentrated acid will be sufficient to neutralize three parts of slaked lime. The saponified fat now liberated from the lime, which is thrown down to the bottom of the tub in the state of sulphate, is skimmed off the surface of the watery menstruum into a third contiguous tub, where it is washed with water and steam.

The washed mixture of stearic, margaric, and oleic acids, is next cooled in tin pans; then shaved by large knives fixed on the face of a fly-wheel, called a tallow cutter, preparatory to its being subjected in canvas or caya bags to the action of a powerful hydraulic press. Here a large portion of the oleic acid is expelled, carrying with it a little of the margaric. The pressed cakes are now subjected to the action of water and steam once more, after which the supernatant stearic acid is run off, and cooled in moulds. The cakes are then ground by a rotatory rasping-machine to a sort of mealy powder, which is put into canvas bags, and subjected to the joint action of steam and pressure in a horizontal hydraulic press of a peculiar construction, somewhat similar to that which has been long used in London for pressing spermaceti. The cakes of stearic acid thus freed completely from the margaric and oleic acids are subjected to a final cleansing in a tub with steam, and then melted into hemispherical masses called blocks. When these blocks are broken, they display a highly crystalline texture, which would render them unfit for making candles. This texture is therefore broken down or comminuted by fusing the stearine in a plated copper pan, along with one thousandth part of pulverized arsenious acid, after which it is ready to be cast into candles in appropriate moulds. See CANDLE.

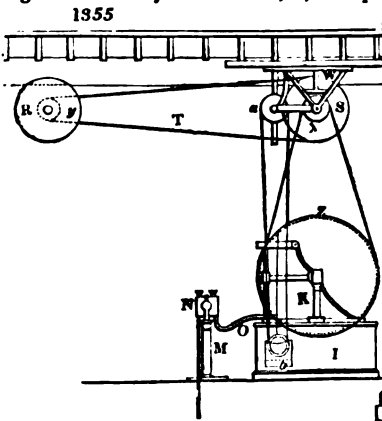
STEARINE COLD PRESS. The cold hydraulic press, as mounted by Messrs. Maudslay and Field, for squeezing out the oleic acid from saponified fat, or the oleine

Scale 3-20ths of an inch to the foot.

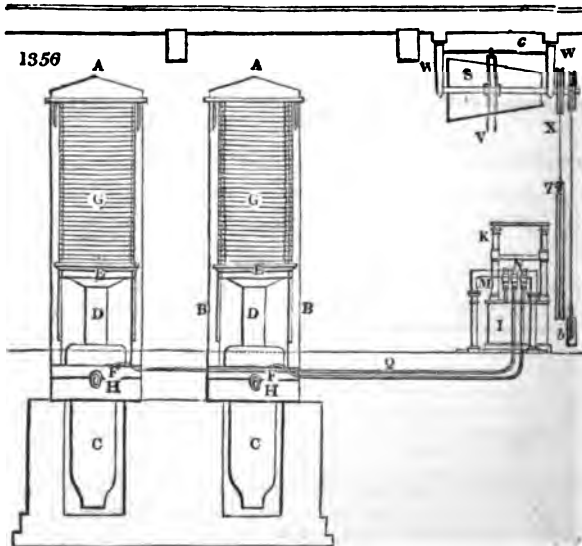


from cocoa-nut lard, is represented in plan in *fig.* 1354; in side view of pump in *fig.* 1355; and in elevation, *fig.* 1356; where the same letters refer to like objects.

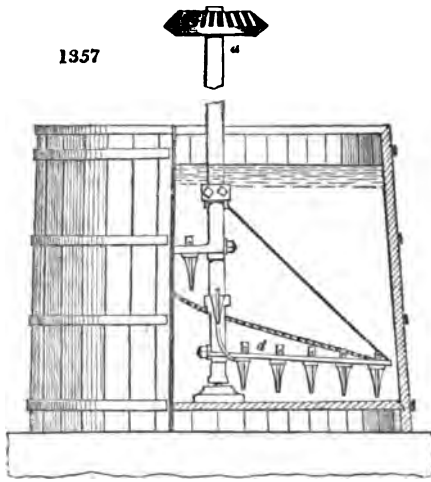
A, A, are two hydraulic presses; a, the frame; c, the cylinder; d, the piston or ram; z, the follower; r, the recess in the bottom to receive the oil; o, twilled woollen bags; with the material to be pressed, having a thin plate of wrought iron between each; s, apertures for the discharge of the oil; i, cistern in which the pumps are fixed; x, framing for machinery to work in; l, two pumps, large and small, to inject the water



into the cylinders; m, a frame containing three double branches; n, three branches, each having two stops or plugs, by which the action of one of the pumps may be intercepted from, or communicated to, one or both of the presses; the large pump is worked at the beginning of the operation, and the small one towards the end; by these branches, one or both presses may be discharged when the operation is finished; o, two pipes from the pumps to the branches; r, pipe to return the water from the cylinders to the cisterns; a, pipes leading from the pumps through the branches to the cylinders; s, conical drum, fixed upon the main shaft r, driven by the steam-engine of the factory; s, a like conical drum to work the pumps; z, a narrow leather strap to communicate the motion from r to s; u, a long screw bearing a nut, which works along the whole length of the drum; v, the fork or guide for moving the strap x; w, w, two hanging bearings to carry the drum s; x, a pulley on the spindle of the drum s; r, the main shaft; z, fly-wheel with groove on the edge, driven by the pulley x; on the axis of s, is a double crank, which works the two pumps l. a, is a pulley on the end of the long screw u; an endless cord passes twice round this pulley, and under a pulley fixed in the weight b; by laying hold of both sides of his cord, and raising or lowering it, the forked guide v, and the leather strap x, are moved backwards or forwards, by means of the nut fixed in the guide, so as to accelerate or retard at pleasure the speed of the working of the pumps; c, is a piece of iron, with a long slit, in which a pin, attached to the fork v, travels, to keep it in the vertical position.

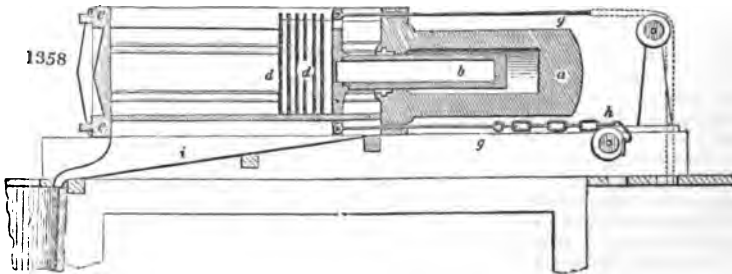


STEARINE. Fig. 1357. is a view of both the exterior and interior of the saponi-



fying tun of a stearine factory; where the constituents of the tallow are combined with quicklime, by the intervention of water and steam; *a*, is the upright shaft of iron, turned by the bevel wheel above, in gear with another bevel wheel on the moving shaft, not shown in this figure. This upright shaft bears several arms *d*, furnished with large teeth. The tun is bound with strong hoops of iron, and its contents are heated by means of a spiral tube laid on the bottom, perforated with numerous holes, and connected by a pipe with a high-pressure steam-boiler.

Fig. 1358. represents a longitudinal section of the horizontal hydraulic press for depriving stearic acid, as also spermaceti, of all their fluid oily impurities. *a*, is the cylinder of the press; *b*, the ram or piston; *i*, *i*, *i*, hair and flannel bags inclosing the impure cakes to be exposed to pressure; *d*, *d*, *d*, *d*, iron plates previously heated, and placed between every two cakes to facilitate the discharge of their oily matter; *e*, *e*, solid iron end of the press, made to resist great pressure; it is strongly bolted to the



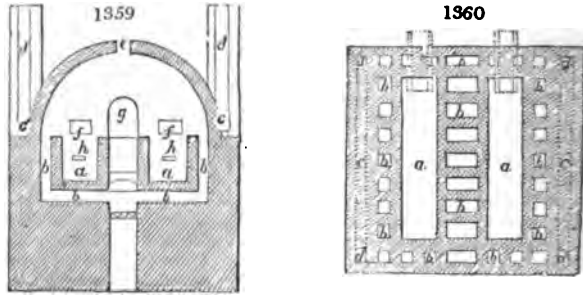
cylinder *a*, so as to resist the force of the ram; *g*, *g*, iron rods, for bringing back the ram *b*, into its place after the pressure is over, by means of counter weights suspended to a chain, which passes over the pulleys *h*, *h*; *i*, *i*, a spout and a sheet-iron pan for receiving the oily fluid.

STEATITE (*Soapstone*; *Craie de Briançon*, Fr.; *Speckstein*, Germ.); is a mineral of the magnesian family. It has a grayish-white or greenish-white colour, often marked with dendritic delineations, and occurs massive, as also in various superstitious crystalline forms; it has a dull or fatty lustre; a coarse splintery fracture, with translucent edges; a shining streak; it writes feebly; is soft, and easily cut with a knife; but somewhat tough; does not adhere to the tongue; feels very greasy; infusible before the blowpipe; specific gravity from 2.6 to 2.8. It consists of—silica, 44; magnesia, 44; alumina, 2; iron, 7.3; manganese, 1.5; chrome, 2; with a trace of lime. It is found frequently in small contemporaneous veins that traverse serpentine in all directions, as

at Portsoy, in Shetland, in the limestone of Icolmkill, in the serpentine of Cornwall, in Anglesey, in Saxony, Bavaria (at Bayreuth), Hungary, &c. It is used in the manufacture of porcelain. It makes the biscuit semi-transparent, but rather brittle, and apt to crack with slight changes of heat. It is employed for polishing serpentine, marble, gypseous alabaster, and mirror glass; as the basis of cosmetic powder; as an ingredient in anti-attrition pastes; it is dusted in powder upon the inside of boots, to make the feet glide easily into them; when rubbed upon grease-spots in silk and woollen clothes, it removes the stains by absorption; it enters into the composition of certain crayons, and is used itself for making traces upon glass, silk, &c. The spotted steatite, cut into cameos and calcined, assumes an onyx aspect. Soft steatite forms excellent stoppers for the chemical apparatus used in distilling or subliming corrosive vapours. Lamellar steatite is TALC.

STEEL (*Acier*, Fr.; *Stahl*, Germ.); as a carburet of iron, has already been considered under that metal. I shall treat in this article more particularly of its manufacture and technical relations.

1. *Steel of cementation, bar or blistered steel.* — With the exception of the Ulverstone charcoal iron, no bars are manufactured in Great Britain capable of conversion into steel at all approaching in quality to that made from the Madras, Swedish, and Russian irons, so largely imported for that purpose. The first rank is assigned to the Swedish iron stamped with a circle enclosing the letter L (hence called hoop L); which fetches the high price of 26*l.* 10*s.* per ton, while excellent English coke-iron may be had for one-fourth of the price. The other Swedish irons are sold at a much lower rate, though said to be manufactured in the same way; and therefore the superiority of the Daffnemora iron must be owing to some peculiarity in the ore from which it is smelted. The



steel recently made at Sheffield in the works of the weldable cast steel from Mr. Heath's Madras iron, rivals that from the hoop L.

The Sheffield furnace for making bar or blistered steel, called the furnace of cementation, is represented in *fig.* 1359, in a cross section, and in *fig.* 1360, in a ground plan. The hearth of this oblong quadrangular furnace, is divided by a grate into two parts, upon each side of which there is a chest *a*, called a *trough*, made of fire-clay, or fire-tiles. The breadth of the grate varies according to the quality of the fuel. *b, b*, are air-holes; *c, c*, flues leading to the chimney *d, d*. To aid the draught of the smoke and the flame, an opening *e*, is made in the middle of the flat arch of the furnace. In one of the shorter sides (ends), there are orifices *f, f*, through which the long bars of iron may be put in and taken out; *g*, is the door by which the steel-maker enters, in filling or emptying the trough; *h*, is a proof hole, at which small samples of the steel in the act of its conversion may be drawn out. The furnace is built under a conical hood or chimney, from 30 to 50 feet high, for aiding the draught, and carrying off the smoke.

The two chests are built of fire-stone grit. They are 8, 10, or even 15 feet long, and from 26 to 36 inches in width and depth; the lower and smaller they are, the more uniform will the quality of the steel be. A great breadth and height of trough are incompatible with equability of the cementing temperature. The sides are a few inches thick. The space between them is at least a foot wide. They should never rest directly upon the sole of the furnace, but must have their bottom freely played upon by the flame, as well as the sides and top. The degree of heat is regulated by openings in the arch, or upon the long sides of the furnace, which lead to the chimney; as also by the greater or less quantity of air admitted below the grate, as in glass-house furnaces.

The *cement* consists of ground charcoal (sometimes of soot), mixed with one-tenth of ashes, and some common salt; the charcoal of hard wood being preferred. Ground

coke is inadmissible, on account of the sulphur, silica, and clay which it generally contains. Possibly the salt serves to vitrify the particles of silica in the charcoal, and thus to prevent their entering into combination with the steel. As for the ashes, it is difficult to discover their use. The best steel may be made without their presence. The bottom of the trough being covered with two inches of the powder of cementation, the bars are laid along in it, upon their narrow edge, the side bar being one inch from the trough, and the rest being from $\frac{1}{2}$ to $\frac{3}{4}$ of an inch apart. Above this first layer of iron bars, fully half an inch depth of the powder is spread, then a new series of bars is stratified, and so on till the trough is filled within six inches of the top. This space is partially filled with old cement powder, and is covered with refractory damp sand. Sometimes the trough is filled to the surface with the old cement, and then closely covered with fire-tiles. The bars should never be allowed to touch each other, or the trough. The fire must be carefully urged from 2 to 4 days, till it acquires the temperature of 100° Wedgewood; which must be steadily maintained during the 4, 6, 8, or 10 days requisite for the cementation; a period dependent on the size of the furnace, and which is determined by the examination of the proof pieces, taken out from time to time.

In the front or remote end of the furnace, *fig. 1359.*, a door is left in the outer building, corresponding to a similar one in the end of the interior vault, through which the workman enters for charging the furnace with charcoal and iron bars, as also for taking out the steel after the conversion. Small openings are likewise made in the ends of the chests, through which the extremities of a few bars are left projecting, so that they may be pulled out and examined, through small doors opposite to them in the exterior walls. These *top holes*, as they are called, should be placed near the centre of the end stones of the chests, that the bars may indicate the average state of the process. The joinings of the fire-stones are secured with a finely ground Stourbridge clay.

The interval between the two chests (in furnaces containing two, for many have only one,) being covered with an iron platform, the workman stands on it, and sifts a layer of charcoal on the bottom of the chests evenly, about half an inch thick; he then lays a row of bars, cut to the proper length, over the charcoal, about an inch from each other; he next sifts on a second stratum of charcoal-dust, which, as it must serve for the bars above, as well as below, is made an inch thick; thus, he continues to stratify, till the chest be filled within two inches of the top; and he covers the whole with the earthy detritus found at the bottom of grindstone troughs, or any convenient fire-loam. It is obvious that the second series of bars should correspond vertically with the interstices between the first series, and so in succession. The trial-rods are left longer than the others, and their projecting ends are encrusted with fire-clay, or imbedded in sand. The iron platform being removed, and all the openings into the vault closed, the fire is lighted, and very gradually increased, to avoid every risk of cracking the gristone by too sudden a change of temperature; and the ignition being finally raised to about 100° Wedgewood, but not higher, for fear of melting the metal, must be maintained at a uniform pitch, till the iron have absorbed the desired quantity of carbon, and have been converted as highly as the manufacturer intends for his peculiar object. From six to eight days may be reckoned a sufficient period for the production of steel of moderate hardness, and fit for tilting into shear steel. A softer steel, for saws and springs, takes a shorter period; and a harder steel, for fabricating chisels used in cutting iron, will need longer exposure to the ignited charcoal. But, for a few purposes, such as the bits for boring cast iron, the bars are exposed to two or three successive processes of cementation, and are hence said to be twice or thrice converted into steels. The higher the heat of the furnace, the quicker is the process of conversion.

The furnace being suffered to cool, the workman enters it again, and hands out the steel bars, which being covered with blisters, from the formation and bursting of vesicles on the surface filled with gaseous carbon, is called *blistered steel*. This steel is very irregular in its interior texture, has a white colour, like frosted silver, and displays crystalline angles and facettes, which are larger the further the cementation has been urged, or the greater the dose of carbon. The central particles are always smaller than those near the surface of the bar.

In such a furnace as the above, twelve tons of bar iron may be converted at a charge. But other furnaces are constructed with one chest, which receives six or eight tons at a time; the small furnaces, however, consume more fuel in proportion than the larger.

The absorption and action of the carbonaceous matter, to the amount of about a half per cent., occasions fissures and cavities in the substance of the blistered bars, which render the steel unfit for any useful purpose in tool-making, till it be condensed and rendered uniform by the operation of *tilting*, under a powerful hammer driven by machinery. See IRON.*

* For minute details of the parts, see the excellent article *TILTING-HAMMER*, in *Roe's Cycl. pædia*

The heads of the tilt-hammers for steel weigh from one and a half to two hundred pounds. Those in the neighbourhood of Sheffield are much simpler than the one referred to in the note. They are worked by a small water-wheel, on whose axis is another wheel, bearing a great number of cams or wipers on its circumference, which strike the tail of the hammer in rapid succession, raise its head, and then let it fall smartly on the hot metal rod, dexterously presented on its several parts to the anvil beneath it by the workman. The machinery is adapted to produce from 300 to 400 blows per minute; which on this plan requires an undue and wasteful velocity of the float-boards. Were an intermediate toothed wheel substituted between the water-wheel and the wiper-wheel, so that while the former made one turn, the latter might make three, a much smaller force of water would do the work. The anvils of the tilt-hammer are placed nearly on a level with the floor of the mill-house; and the workman sits in a fume, dog on purpose, in a direction perpendicular to the line of the belve, on a board suspended from the roof of the building by a couple of iron rods. On this swinging seat, he can advance or retire with the least impulse of his feet, pushing forward the steel bar, or drawing it back with equal rapidity and convenience.

At a small distance from each tilt stands the forge-hearth, for heating the steel. The bellows for blowing the fire are placed above-head, and are worked by a small crank fixed on the end of the axis of the wheel, the air being conveyed by a copper pipe down to the nozzle. Each workman at the tilt has two boys in attendance, to serve him with hot rods, and to take them away after they are hammered. In small rods, the bright ignition originally given at the forge soon declines to darkness; but the rapid impulses of the tilt revive the redness again in all the points near the hammer; so that the rod, skilfully handled by the workman, progressively ignites where it advances to the strokes. Personal inspection alone can communicate an adequate idea of the precision and celerity with which a rude steel rod is stretched and fashioned into an even, smooth, and sharp-edged prism, under the operation of the tilt-hammer. The heat may be clearly referred to the prodigious friction among the particles of so cohesive a metal, when they are made to slide so rapidly over each other in every direction during the elongation and squaring of the rod.

2. *Shear steel* derives its name from the accidental circumstance of the shears for dressing woollen cloth being usually forged from it. It is made by binding into a bundle, with a slender steel rod, four parallel bars of blistered steel, previously broken into lengths of about 18 inches, including a fifth of double length, whose projecting end may serve as a handle. This faggot, as it is called, is then heated in the forge-hearth to a good welding heat, being sprinkled over with sand to form a protecting film of iron slag, carried forthwith to the tilt, and notched down on both sides to unite all the bars together, and close up every internal flaw or fissure. The mass being again heated, and the binding rings knocked off, is drawn out into a uniform rod of the size required. Manufacturers of cutlery are in the habit of purchasing the blistered bars at the conversion furnaces, and sending them to tilt-mills to have them drawn out to the proper size, which is done at regular prices to the trade; from 5 to 8 per cent. discount being allowed on the rude bars for waste in the tilting. The metal is rendered so compact by the welding and hammering, as to become susceptible of a much finer polish than blistered steel can take; while the uniformity of its body, tenacity, and malleability are at the same time much increased; by which properties it becomes well adapted for making table knives and powerful springs, such as those of gun-locks. The steel is also softened down by this process, probably from the expulsion of a portion of its carbon during the welding and subsequent heats; and if these be frequently or awkwardly applied, it may pass back into common iron.

3. *Cast steel* is made by melting, in the best fire-clay crucibles, blistered steel, broken down into small pieces of convenient size for packing; and as some carbon is always dissipated in the fusion, a somewhat highly converted steel is used for this purpose. The furnace is a square prismatic cavity, lined with fire-bricks, 12 inches in each side, and 24 deep, with a flue immediately under the cover, $3\frac{1}{2}$ inches by 6, for conducting the smoke into an adjoining chimney of considerable height. In some establishments a dozen such furnaces are constructed in one or two ranges, their tops being on a level with the floor of the laboratory, as in brass-foundries, for enabling the workmen more conveniently to inspect, and lift out, the crucibles with tongs. The ash-pits terminate in a subterraneous passage, which supplies the grate with a current of cool air, and serves for emptying out the ashes. The crucible stands, of course, on a sole-piece of baked fire-clay; and its mouth is closed with a well-fitted lid. Sometimes a little bottle-glass, or blast-furnace slag, is put into the crucible, above the steel pieces, to form a vitreous coating, that may thoroughly exclude the air from oxidizing the metal. The fuel employed in the cast-steel furnace is a dense coke, brilliant and sonorous, broken into pieces about the size of an egg, one good charge of which is sufficient. The tongs are furnished at the fire end with a pair of concave jaws, for embracing the

curvature of the crucible, and lifting it out whenever the fusion is complete. The lid is then removed, the slag or scorizæ cleared away, and the liquid metal poured into cast-iron octagonal or rectangular moulds, during which it throws out brilliant scintillations.

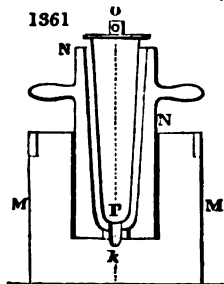
The late ingenious Josiah M. Heath, Esq., discovered that 1 per cent. of carburet of manganese fused with cast steel greatly improved it, and made it weldable.

Cast-iron works much harder under the hammer than sheer steel; and will not, in its usual state, bear much more than a cherry-red heat without becoming brittle; nor can it bear the fatigue incident to the welding operation. It may, however, be firmly welded to iron, through the intervention of a thin film of vitreous boracic acid, at a moderate degree of ignition. Cast steel, indeed, made from a less carburetted bar steel, would be susceptible of welding and hammering at a higher temperature; but it would require a very high heat for its preparation in the crucible.

Iron may be very elegantly plated with cast steel, by pouring the liquid metal from the crucible into a mould containing a bar of iron polished on one face. In this circumstance the adhesion is so perfect as to admit of the two metals being rolled out together; and in this way the chisels of planes and other tools may be made, at a moderate rate and of excellent quality, the cutting edge being formed in the steel side. Such instruments combine the toughness of iron with the hardness of steel.

For correcting the too high carbonization of steel, or equalizing the too highly converted exterior of a bar with the softer steel of the interior, the metal requires merely to be imbedded, at a cementing heat, in oxide of iron or manganese; the oxygen of which soon abstracts the injurious excess of carbon, so that the outer layers may be even converted into soft iron, while the axis continues steely; because the decarbonizing advances far more rapidly than the carbonizing.

Fig. 1361. represents the mould for making crucibles for the cast-steel works. *x, x*, is a solid block of wood, to support the two-handed outside mould *x, x*. This being rammed full of the proper clay dough or compost (see *CRUCIBLE*), the inner mould is to be then pressed vertically into it, till it reaches the bottom *r*, being directed and facilitated in its descent by the point *k*. A cord passes through *o*, by which the inner mould is suspended over a pulley, and guided in its motions.



When a plate of polished steel is exposed to a progressive heat, it takes the following colours in succession: 1. a faint yellow; 2. a pale straw-colour; 3. a full yellow; 4. a brown yellow; 5. a brown with purple spots; 6. a purple; 7. a bright blue; 8. a full blue; 9. a dark blue, verging on black; after which the approach to ignition supercedes all these colours. If the steel plate has been previously hardened by being dipped in cold water or mercury when red-hot, then those successive shades indicate or correspond to successive degrees of softening or tempering. Thus, No. 1. suits the hard temper of a lancet, which requires the finest edge, but little strength of metal; No. 2. a little softer, for razors and surgeons' amputating instruments; No. 3. somewhat more toughness, for penknives; No. 4. for cold chisels and shears for cutting iron; No. 5. for axes and plane-irons; No. 6. for table knives and cloth shears; No. 7. for swords and watch springs; No. 8. for small fine saws and daggers; No. 9. for large saws, whose teeth need to be set with pliers, and sharpened with a file. After ignition, if the steel be very slowly cooled, it becomes exceedingly soft, and fit for the engraver's purposes. Hardened steel may be tempered to the desired pitch, by plunging it in metallic baths heated to the proper thermometric degree, as follows: for No. 1. 430° Fahr.; No. 2. 450°; No. 3. 470°; No. 4. 490°; No. 5. 510°; No. 6. 530°; No. 7. 550°; No. 8. 560°; No. 9. 600°.

Small steel tools are most frequently tempered, after hardening, by covering their surface with a thin coat of tallow, and heating them in the flame of a candle till the tallow diffuses a faint smoke, and then thrusting them into the cold tallow. Rinman long ago defined steel to be any kind of iron which, when heated to redness, and then plunged in cold water, becomes harder. But several kinds of cast-iron are susceptible of such hardening. Every malleable and flexible iron, however, which may be hardened in that way, is a steel. Moreover, steel may be distinguished from pure iron by its giving a dark-gray spot when a drop of dilute nitric acid is let fall on its surface, while iron affords a green one. Exposed to the air, steel rusts less rapidly than iron; and the more highly carburetted, the more slowly does it rust, and the blacker is the spot left by an acid.

After hardening, steel seems to be quite a different body; even its granular texture becomes coarser or finer according to the degree of heat to which it was raised; it grows so hard as to scratch glass, and resist the keenest file, while it turns exceedingly

brittle. When a slowly cooled steel rod is forged and filed, it becomes capable of affording agreeable and harmonious sounds by its vibrations; but hard-tempered steel affords only dull deafened tones, like those emitted by a cracked instrument.

The good quality of steel is shown by its being homogeneous; being easily worked at the forge; by its hardening and tempering well; by its resisting or overcoming forces; and by its elasticity. To ascertain the first point, the surface should be ground and polished on the wheel; when its lustre and texture will appear. The second test requires a skilful workman to give it a heat suitable to its nature and state of conversion. The size and colour of the grain are best shown by taking a bar forged into a razor form; hardening and tempering it; and then breaking off the thin edge in successive bits with a hammer and anvil. If it had been fully ignited only at the end, then, after the hardening, it will display, on fracture, a succession in the aspect of its grains from that extremity to the other; as they are whiter and larger at the former than the latter. The other qualities become manifest on filing the steel; using it as a chisel for cutting iron; or bending it under a heavy weight.

Much interest was excited a few years back by the experiments of Messrs. Stodart and Faraday on the alloys of steel with silver, platinum, rhodium, and iridium. Steel refuses to take up in fusion more than one five-hundredth part of silver; but with this minute quantity of alloy, it is said to bear a harder temper, without losing its tenacity. When pure iron is substituted for steel, the alloys so formed are much less subject to oxidation in damp air than before. With three *per cent.* of iridium and osmium, an alloy was obtained, which had the property of tempering like steel, and of remaining clean and bright, in circumstances when simple iron became covered with rust. "Upon the whole," says the editor of the Quarterly Journal of Science, giving a report of these experiments in his 14th volume, p. 378, "though we consider these researches upon the alloys of steel as very interesting, we are not sanguine as to their important influence upon the improvement of the manufacture of cutlery, and suspect that a bar of the best ordinary steel, selected with precaution, and most carefully forged, wrought, and tempered, *under the immediate inspection of the master*, would afford cutting instruments as perfect and excellent as those composed of wootz, or of the alloys.

The patent plan of Mr. William Onions of making cast steel seems worthy of adoption. He takes two parts by weight of hæmatite ore (such as that of Cumberland) reduced to a state of coarse powder, and puts them into a crucible; he then adds thereto four parts, by weight, of steel, made in the ordinary way, and ninety-four parts of iron, broken into small pieces, the iron used being that made from Cumberland ore, or other iron which can be rendered malleable by annealing; and he melts these materials together. Instead of first running the metal into ingots or bars, and then remelting it, he casts it at once in sand moulds, into the articles required to be formed of cast steel. These castings are rendered malleable by the process of annealing, and may be tempered in the same way as articles made of ordinary steel. The annealing process employed is that by which castings of iron, made from Cumberland and like ores, are rendered malleable. The articles are put into pots or boxes with pulverized Cumberland ore, or other matter usually employed and subjected to heat, in an annealing oven, for a time dependent upon the thickness or substance of the articles under treatment. The articles which are annealing at the same time should therefore be as nearly as possible of the same thickness; and the heat should not be permitted to increase rapidly, nor to attain too high a temperature. The time required for the annealing processes will be ascertained by practice. To anneal articles about an inch square (supposing the metal to be in bars of that thickness) they should be kept at a red heat for 120 hours: the time occupied in raising them to that heat should be 14 hours, and after they have been kept at a red heat for 10 hours, they should be allowed to cool down very gradually, say in not less than 24 hours. The articles thus annealed may be turned or otherwise reduced to the desired shape by the ordinary tools, and may be tempered in the same manner as articles made of common cast steel.

The patentee does not confine himself to the above details; but he claims the mode of manufacturing cast-steel by melting matters together and annealing the products, as above described.

Case-hardening of iron, is a process for converting a thin film of the outer surface into steel, while the interior remains as before. Fine keys are generally finished in this way. See CASE-HARDENING.

So great is the affinity of iron for carbon, that, in certain circumstances, it will absorb it from carburetted hydrogen, or coal-gas, and thus become converted into steel. On this principle, Mr. Mackintosh of Glasgow obtained a patent for making steel. His furnace consists of one cylinder of bricks built concentrically within another. The bars of iron are suspended in the innermost, from the top; a stream of purified coal-gas circulates freely round them, entering below and escaping slowly above, while the bars are maintained in a state of bright ignition by a fire burning in the annular space between the

cylinders. The steel so produced is of excellent quality; but the process does not seem to be so economical as the ordinary cementation with charcoal powder.

Damasking of steel, is the art of giving to sabre blades a variety of figures in the style of watering. See DAMASCUS BLADES.

Several explanations have been offered of the change in, the constitution of steel which accompanies the tempering operation; but none of them seems quite satisfactory. It seems to be probable that the ultimate molecules are thrown by the sudden cooling into a constrained state, so that their poles are not allowed to take the position of strongest attraction and greatest proximity; and hence the mass becomes hard, brittle, and somewhat less dense. An analogous condition may be justly imputed to hastily cooled glass, which, like hardened steel, requires to be annealed by a subsequent nicely graduated heat, under the influence of which the particles assume the position of repose, and constitute a denser, softer, and more tenacious body. The more sudden the cooling of ignited steel, the more unnatural and constrained will be the distribution of its particles, and also the more refractory, an effect produced by plunging it into cold mercury. This excess of hardness is removed in any required degree by judicious annealing or tempering. The state of the carbon present in the steel may also be modified by the rate of refrigeration, as Mr. Karsten and M. Bréant conceive happens with cast iron and the damask metal. If the uniform distribution and combination of the carbon through the mass determine the peculiarity of white cast iron, which is a hard and brittle substance, and if its transition to the dark-gray and softer cast metal be effected by a partial formation of plumbago during slow cooling, why may not something similar be supposed to occur with steel, an analogous compound?

Mr. Oldham, printing engineer of the Bank of England, who had had great experience in the treatment of steel for dies and mills, said that, for hardening it, the fire should never be heated above the redness of red sealing-wax, and kept at that pitch for a sufficient time. On taking it out, he hardened it by plunging it, not in water, but in olive oil, or rather naphtha, previously heated to 200° F. It is kept immersed only till the ebullition ceases, then instantly transferred into cold spring water, and kept there till quite cold. By this treatment the tools come out perfectly clean, and as hard as it is possible to make cast-steel, while they are perfectly free from cracks, flaws, or twist. Large tools are readily brought down in temper by being suspended in the red-hot muffle till they show a straw-colour; but for small tools, he preferred plunging them in the oil heated to 400°; and leaving them in till they became cold.

Mr. Oldham softened his steel dies by exposing them to ignition for the requisite time, imbedded in a mixture of chalk and charcoal.

"The common mode of softening steel," says Mr. Baynes, "is to put it into an iron case, surrounded with a paste made of lime, cow's gall, and a little nitre and water; then to expose the case to a slow fire, which is gradually increased to a considerable heat, and afterwards allowed to go out, when the steel is found to be soft and ready for the engraver."*

Steel, manufacture of.—Iron in the composition of which a portion of the silica is replaced by manganese, will while being smelted rather part with the latter than the former. From this it follows, that at the moment when the iron is on the point of passing from a liquid to a solid state it will retain sufficient silica to form steel. For this reason, during the whole process of refining, the current of air is caused to act rather upon the surface of the metal than through the interior of the fluid mass, in order to avoid the combustion of too much carbon and silica; from which it follows that the casting becomes malleable without losing a sufficient quantity of silica to constitute iron, properly so called, and the product is raw or blistered steel. The casting which does not contain any manganese loses by the effect of combustion a portion of silica proportionable to the quantity of carbon burnt, and furnishes iron only as a definite product.

It is simply to the mechanical action of the hammer, that the distinctive features of bar steel, as compared with that of cast steel, are due. In order to effect this change, the blistered steel is broken into pieces and melted down; they are afterwards tempered, again broken into pieces, and welded together at a good welding heat. The steel will be the more malleable, and possess more tenacity and uniformity of texture, in proportion to the number of times these operations are repeated. The product is called "wrought or shear steel."

Steel of cementation and cast steel.—When bar iron is heated to a white heat, or even melted in close vessels containing coal or carbonaceous substances, it takes up a certain quantity of carbon, and is transformed into cast-steel of various kinds.

If the iron contains together with silica, phosphorus and arsenic in proportions suit-

* History of the Cotton Manufacture, p. 269. If that strange farrago be employed by Mr. Locket of Manchester, for softening his dies and mills, it deserves consideration. Should the nitre be used in too great quantity to be all carbonated by the gall, its oxygen may serve to consume some of the carbon of the steel, and thus bring it nearer to iron. The recipe may be old, but it is a novelty to me.

able for softening the granular particles of iron during their combination with the carbon, by keeping it for a certain time at a red heat with powdered charcoal, a casting is obtained, which, when submitted to the action of the hammer or rollers, furnishes a product known as "steel of cementation." During this operation the stratum of oxide which covers the particles of iron inside loses its oxygen, and passes again into a metallic state; but the vacant spaces occasioned by this are filled up, as the ferruginous particles, which are in a semi-fluid state, reassume the crystalline form. The carbonic acid (oxide?) gas in escaping forms large blisters on the surface of the metal, under which the softened mass crystallizes. On being broken, the interior of these blisters, instead of appearing of a dark colour, indicating the presence of a stratum of protoxide, presents a brilliant and rainbow-tinted appearance, the yellowish and bluish tints distinguishing bronzed steel being observable. If this steel be wrought at a white heat, these blisters will weld in with the mass with the greatest facility. During cementation the carbon combines with the component particles of the iron in various proportions, depending in a great degree upon the chemical composition of those particles. It is therefore a vulgar error to suppose that steel of cementation contains more carbon at the surface than in the interior, as stated in all technological treatises. Thus, in the best Dannemora steel, it very frequently happens, when the cementation is finished, that the centre of the metal contains a much greater quantity of carbon than in the superficial portions. It may also happen that steel produced from the best Dannemora bar iron will differ in an extraordinary manner as regards hardness in various portions of the bar; and for this reason, in steel works in England, the bars of steel are always broken into several pieces, in order to class those pieces together which are the most similar in quality.

If ordinary iron be submitted to cementation, that is to say, iron in which the proportion of silica is ordinarily insignificant when compared with that of carbon, and if independently of this, the iron is deficient in the quantity of phosphorus and arsenic necessary for easily softening the metallic molecules, only carburet of iron and a little siliciuret of iron are produced, but the carbon does not combine with the silica. In this case the steel is deficient in malleability and tenacity, for this reason, that the molecules will not unite or crystallize until they have taken up a quantity of carbon more than sufficient to produce steel. With regard to simple carburetted iron (when it contains more carbon), it either will not harden at all when tempered, or becomes friable and brittle when heated to redness, even when it does not contain more carbon than steel of good quality.

The fracture of the steel of cementation, now under notice, is gray and dull, while steel of good quality is of a silvery aspect, and presents cubical crystals.

The best steel can only be obtained by the cementation of forged iron: whilst the metal is combining with the carbon, the iron must not enter into a complete state of fusion, as in that case groups of crystals, each possessing a different degree of carbonization, would be formed; even the best Dannemora iron will not furnish a uniform product, fit for purposes of commerce, when melted with substances containing carbon. I am well aware that the experiments of Clouet, Hachette, and Bréant may be opposed to me, as set forth in various treatises on chemistry; but these are unfortunately mere laboratory experiments, the authors of which have prudently concealed, or passed over in silence, all those which were unsuccessful. When the operator has obtained a regulus at the bottom of his crucible, and when, after immense trouble, he has succeeded in extracting a small portion of steel capable of being worked, he immediately hastens to publish his pretended discovery in some journal, of which others become faithful and credulous echoes: thus, since the manufacture of steel has become the subject of chemical inquiry, complaints are daily becoming more frequent upon the difficulty of obtaining steel capable of resisting the treatment to which it is subjected in the arts. If the persons who preside over the coining department either at London or Munich were consulted, they would all agree in saying that it is now very difficult to meet with the quality of steel necessary for making the dies. Even in England good steel becomes more and more scarce. With regard to the manufactories of cemented or cast steel established upon the Continent, they furnish products the quality of which is so uncertain that the workman is often reduced, after having lost his time and trouble, to throw certain portions away, as they want the necessary uniformity and tenacity.

All the artificial alloys of silver with steel, of which so much has been said, are not fit for anything, and are never met with in commerce.

When the steel has been withdrawn from the cementing furnace, and after it has been broken and the pieces drawn out, they are submitted to one of the two following operations:—The pieces, after being sorted, are piled one upon the other and welded together (this is called faggoting the steel); or the sorted pieces are placed in clay crucibles of a nearly cylindrical form, and cast in a reverberatory furnace, in which two crucibles are placed, one behind the other, upon cakes of fire clay; the orifice of these crucibles is closed by a flat cake of fire clay. The bars of cemented steel, as above

mentioned, are divided into pieces of one or two inches in length; these pieces are distributed, according to their degree of carbonization, in vessels fixed to the walls of the place in which the melting is carried on.

These different qualities of steel are generally combined in such a manner as to obtain a product the best suited for the purposes to which cast steel is ordinarily applied.

In all treatises on practical chemistry it is asserted that, in order to melt steel, it is to be covered with a layer of glass or blast furnace slag; that the opening of the crucible is luted, or at least becomes firmly fixed during the operation; these assertions are however erroneous. In the first steel manufactories in Sheffield, steel only is put into the crucibles. With regard to the cover it is evident that it must not adhere to the crucible, as it is necessary the operator should remove it from time to time with a bar of iron in order to ascertain the state of the metal.

In order to obtain steel of the best quality, it is not sufficient that the melted mass be run into moulds; the most essential point is to make the casting at the proper time, and for this purpose the operator must be guided by the quality of the steel. This is the duty of the workman, who from long practice can tell the suitable point of fusion, either by simple inspection or by means of his bar of iron, with which he merely touches the surface of the metal, being most careful not to plunge it into the melted mass. As the quality and uniformity of the steel depend in a great measure upon the experience and judgment of the workman who directs the casting, it follows that, even in England, a good caster is much sought after and well paid.

It is not difficult therefore to explain why so many of the attempts made to establish manufactories of cast steel in Germany have failed, and will again fail. Thanks to the errors propagated by technical works, and by the assertions of superficially informed travellers, who had frequently been purposely deceived, it was imagined that in order to obtain English steel of good quality, it was only necessary to melt cemented steel in a crucible, and afterwards pour it into moulds when in a state of fusion.

As soon as a crucible is emptied, it is replaced in the oven; each crucible serves for one day's work, *i. e.* four or five castings, after which it is thrown aside. For ordinary purposes, the steel is run into cast-iron moulds of a prismatic form, previously heated and closed. When the steel is required for making saw-blades, plates, &c., it is run into large moulds of a parallelepiped form. Steel which is very hard and highly carbonized, contracts considerably in the moulds; great skill is therefore required to run it into the moulds in such a manner that no vacuum may be produced. In that part of the prism corresponding to the jet, a funnel shaped aperture from 1 to 2 inches deep is formed; this is detached and melted down with other pieces of steel.

The transverse fracture of a prism of hard steel is silvery, and has a number of rays radiating from the centre; steel less hard is, on the contrary, of a uniform granular and crystalline texture. This steel possesses all the brittleness of cast metal.

By fusion, steel of cementation acquires peculiar properties, and does not sweat so much as before casting.

When steel is produced from iron of bad quality, and carburets of a different nature are produced during cementation, the melting, instead of improving it, renders it much worse; as, in that case, the different carburets of iron, which are of inferior quality, separate still more during cooling. This has given rise to an old saying, well known among English founders, that "when the devil is put into the crucible, nothing but the devil will come out."

It is to the existence of these heterogeneous metallic carburets, which are produced during cementation in iron of inferior quality, and which form new combinations during the fusion of the metal, that the complaints of workmen working in steel are to be attributed. In fact, these carburets being only, so to speak, agglutinated, even in bars of forged steel, each of them at the moment of tempering is contracted or dilated more or less than the one immediately adjoining it, so that from that time a separation commences between the unequally carbonized layers; in other words, a flaw or crack is produced, which may be distinguished by a peculiar noise at the moment when the steel is plunged in the water, or at least there is a tendency to separation, which only requires the cooperation of an exterior cause, such as a shock, to effect. This is often observed in razors, &c.

The transverse fracture of cast steel ought to present a perfectly homogeneous surface when the bar is broken by a sharp blow, after being cut or marked with a chisel. The slight inequalities which are perceptible ought to be undulating, and to blend insensibly at their bases with the rest of the metallic surface. When, on the contrary, they stand out perpendicularly, the conclusion may be arrived at, that this portion of the bar was the point of contact of two unequally carbonized layers, which, by separating either at the moment of tempering or at a later period, had inevitably given rise to this rupture.

Indian steel, or wootz. — The wootz ore consists of the magnetic oxide of iron, united with quartz, in proportions which do not seem to differ much, being generally about 42

of quartz and 58 of magnetic oxide. Its grains are of various size, down to a sandy texture. The natives prepare it for smelting by pounding the ore, and winnowing away the stony matrix, a task at which the Hindoo females are very dexterous. The manner in which iron ore is smelted and converted into wootz or Indian steel, by the natives at the present day, is probably the very same that was practised by them at the time of the invasion of Alexander; and it is a uniform process, from the Himalaya mountains to Cape Comorin. The furnace or bloomery in which the ore is smelted is from 4 to 5 feet high; it is somewhat pear-shaped, being about 2 feet wide at bottom, and 1 foot at top; it is built entirely of clay, so that a couple of men can finish its erection in a few hours, and have it ready for use the next day. There is an opening in front about a foot or more in height, which is built up with clay at the commencement and broken down at the end of each smelting operation. The bellows are usually made of a goat's skin, which has been stripped from the animal without ripping open the part covering the belly. The apertures at the legs are tied up, and a nozzle of bamboo is fastened in the opening formed by the neck. The orifice of the tail is enlarged and distended by two slips of bamboo. These are grasped in the hand, and kept close together in making the stroke for the blast; in the returning stroke they are separated to admit the air. By working a bellows of this kind with each hand, making alternate strokes, a pretty uniform blast is produced. The bamboo nozzles of the bellows are inserted into tubes of clay, which pass into the furnace at the bottom corners of the temporary wall in front. The furnace is filled with charcoal, and a lighted coal being introduced before the nozzles, the mass in the interior is soon kindled. As soon as this is accomplished, a small portion of the ore, previously moistened with water, to prevent it from running through the charcoal, but without any flux whatever, is laid on the top of the coals, and covered with charcoal to fill up the furnace.

In this manner ore and fuel are supplied; and the bellows are urged for 3 or 4 hours, when the process is stopped; and the temporary wall in front being broken down, the bloom is removed by a pair of tongs from the bottom of the furnace. It is then beaten with a wooden mallet, to separate as much of the scoriæ as possible from it, and, while still red-hot, it is cut through the middle, but not separated, in order merely to show the quality of the interior of the mass. In this state it is sold to the blacksmiths, who make it into bar iron. The proportion of such iron made by the natives from 100 parts of ore is about 15 parts. In converting the iron into steel, the natives cut it into pieces, to enable it to pack better in the crucible, which is formed of refractory clay mixed with a large quantity of charred husk of rice. It is seldom charged with more than a pound of iron, which is put in with a proper weight of dried wood chopped small, and both are covered with one or two green leaves; the proportions being in general 10 parts of iron to 1 of wood and leaves. The mouth of the crucible is then stopped with a handful of tempered clay, rammed in very closely, to exclude the air. The wood preferred is the *Cassin auriculata*, and the leaf that of the *Aclepias gigantea*, or the *Convolvulus laurifolius*. As soon as the clay plugs of the crucibles are dry, from 20 to 24 of them are built up in the form of an arch, in a small blast furnace; they are kept covered with charcoal, and subjected to heat urged by a blast for about two hours and a half, when the process is considered to be complete. The crucibles being now taken out of the furnace and allowed to cool, are broken, and the steel is found in the form of a cake, rounded by the bottom of the crucible. When the fusion has been perfect, the top of the cake is covered with strizæ, radiating from the centre, and is free from holes and rough projections; but if the fusion has been imperfect, the surface of the cake has a honeycomb appearance, with projecting lumps of malleable iron. On an average, four out of five cakes are more or less defective. These imperfections have been tried to be corrected in London by re-melting the cakes, and running them into ingots; but it is obvious, that when the cakes consist partially of malleable iron and of unreduced oxide, simple fusion cannot convert them into good steel. When care is taken, however, to select only such cakes as are perfect, to re-melt them thoroughly, and tilt them carefully into rods, an article has been produced which possesses all the requisites of fine steel in an eminent degree. In the Supplement to the Encyclopædia Britannica, article *Cutlery*, the late Mr. Stodart, of the Strand, a very competent judge, has declared "that for the purposes of fine cutlery, it is infinitely superior to the best English cast steel."

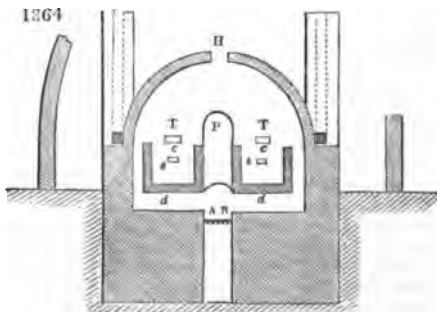
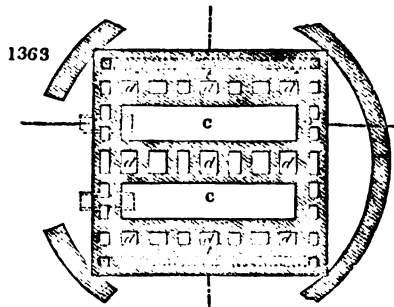
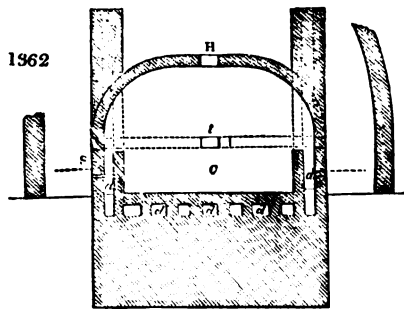
The natives prepare the cakes for being drawn into bars by annealing them for several hours in a small charcoal furnace, actuated by bellows; the current of air being made to play upon the cakes while turned over before it; whereby a portion of the combined carbon is probably dissipated, and the steel is softened; without which operation the cakes would break in the attempt to draw them. They are drawn by a hammer of a few pounds weight.

The natives weld two pieces of cast steel, by giving to each a sloping face, jagged all over with a small chisel, then applying them with some calcined borax between, and tying

them together with a wire, they are brought to a full red heat, and united by a few smart blows of a hammer.

The ordinary bar iron of Sweden and England, when converted by cementation into steel, exhibits upon its surface numerous small warty points, but few or no distinct vesicular eruptions; whereas the Dannemora and the Ulverston steels present, all over the surface of the bars, well raised blisters, upwards of three-eighths of an inch in diameter horizontally, but somewhat flattened at top. Iron of an inferior description, when highly converted in the cementing-chest, becomes gray on the outer edges of the fracture; while that of Dannemora acquires a silvery colour and lustre on the edges, with crystalline facets within. The highly converted steel is used for tools that require to be made very hard; the slightly converted, for softer and more elastic articles, such as springs and sword blades.

One of the greatest improvements which this valuable modification of iron has ever received is due to the late Mr. Josiah M. Heath, who, after many elaborate and costly researches, upon both the small and the great scale, discovered that by the introduction of



a small portion, 1 per cent., and even less, of carburet of manganese into the melting-pot along with the usual broken bars of blistered steel, a cast steel was obtained, after fusion, of

a quality very superior to what the bar steel would have yielded without the manganese, and moreover possessed of the new and peculiar property of being weldable either to itself or to wrought iron. He also found that a common bar-steel, made from an inferior mark or quality of Swedish or Russian iron, would, when so treated, produce an excellent cast steel. One immediate consequence of this discovery has been the reduction of the price of good steel in the Sheffield market by from 30 to 40 per cent., and likewise the manufacture of table-knives of cast steel with iron tangs welded to them; whereas, till Mr. Heath's invention, table-knives were necessarily made of shear-steel, with unseemly wavy lines in them, because cast steel could not be welded to the tangs. Mr. Heath obtained a patent for this and other kindred meritorious inventions on the 5th of April, 1839; but, strange and melancholy to say, he never derived any thing from his acknowledged improvement but vexation and loss, in consequence of a numerous body of Sheffield steel manufacturers having banded together to pirate his patent, and to baffle him in our complex law courts. I hope, however, that eventually justice will have its own, and the ridiculously unfounded pretences of the pirates to the prior use of carburet of manganese will be set finally at rest. It is supposed that fifty persons at least embarked in this pilfering conspiracy. By a recent decision of the Judicial Committee of the Privy Council, the heirs of Mr. Heath have obtained a prolongation of the term of the patent for seven years from this date, February, 1853.

The furnace of cementation in which bar-iron is converted into bar or blistered steel is represented in *figs.* 1362, 63, 64. It is rectangular and covered in by a grained or *cloister* arch: it contains two cementing chests, or sarcophaguses, c, c, made either of fire-stone or fire-bricks: each is $2\frac{1}{2}$ feet wide, 3 feet deep, and 12 long; the one being placed on the one side, and the other on the other of the grate, a, a, which occupies the whole length of the furnace, and is from 13 to 14 feet long. The grate is 14 inches broad, and rests from 10 to 12 inches below the inferior plane or bottom level of the chests; the height of the top of the arch above the chests is $5\frac{1}{2}$ feet; the bottom of the chests is nearly on a level with the ground, so that the bars do not need to be lifted high in charging the furnace. The flame rises between the two chests, passes also below and round them through horizontal and vertical flues, d, and issues from the furnace by an opening, e, in the top of the vault, and by orifices, f, which communicate with the chimneys placed in the angles. The whole is placed within a large cone of bricks, 25 or 30 feet high, and open at top: this cone increases the draught, makes it more regular, and carries off the smoke away from the establishment. The furnace has three doors; two, r (*fig.* 1363), above the chests, serve to admit and to remove the bars; they are about 7 or 8 inches square: in each of them a piece of sheet-iron is put, folded back on its edges; upon which the bars are made to slide, so as to save the wall. A workman enters by the middle door, s, to arrange the bars; the trial bars are taken out from time to time by the apertures, v, (*fig.* 1362.) left in the sides of the chests. The bars are laid in strata, along with wood charcoal in powder, in the said chests; they are about 3 inches broad, and one-third of an inch thick; they must not be placed too near each other, lest they should get welded together; the last or uppermost layer is covered with a stratum of loamy matter from 4 to 5 inches thick. The furnace must be gradually heated, not reaching its maximum temperature before 8 or 9 days, and the cooling lasts 5 or 6 days; the whole operation 18 or 20 days, and sometimes more, according to the quality of the steel to be cemented. About 13 tons of coals are consumed in this period. It is of consequence that the refrigeration be slow, to favour the crystallisation of the metal. The grain of the steel varies with the rate of cooling, the largest and whitest grain denoting the most fusible steel.

Heavy Steel. R. Thomas, *Ironfield works, Birmingham, manufacturer.* The articles exhibited illustrated the heavy steel "toy" trade of Birmingham. Brazil axes; American wedge axes, and hand hatchet; shingling hatchets, assorted patterns; coopers' adze and axe; round and square eye adze; mahogany squaring axe; English carpenter's axe; eyed shell and screw auger; double plane iron; socket chisel; trowel; gun and hand harpoons; improved grass shears; and a variety of garden tools, to screw into one handle. The manufacture of the axe used by the backwoods-men, of the hoe used in the agriculture of the tropics, the pick used by the Caffirs of the Cape, and the harpoon of the whale-fisher, give employment to many artisans of its vicinity. In order to convey a general idea of the process by which these articles are "got up," the manufacture of an ordinary axe may be selected. A piece of iron is taken, and after being heated is doubled over a piece of steel, corresponding in form to the future eye which is to hold the shank; it is not then welded together. A small piece of steel which is intended to form the future cutting edge, is heated along with the iron back to a welding heat, and is passed under a tilt hammer (that is, a large hammer driven by steam or water), which speedily flattens it out; it is then exposed to another heat, and the eye is completed with the small hammer. The superfluous iron or steel is removed by a pair of large scissors. The

process of hardening and tempering follow; the grinding is performed on stones which cut away the iron and disclose the steel edge. The "glazing" on emery "bobs" or wheels succeeds, and the polishing is effected by means of emery and oil on a similar tool. Considerable improvement in appearance is imparted by the use of a blue varnish which is applied to the axe, and drying in a small stove. "Toy" is a technical term applied to an anvil, a hammer, and various other objects which are comprised under the term "heavy steel."

In the year 1843, 25,000 tons of steel were annually converted in this country, and of that quantity not more than 2,500 were made from the best Swedish iron.

For the remainder, inferior qualities of iron, such as the Russian iron marked CCND, from the forges of Count Demidoff, were used; that iron was made with charcoal, and could be called inferior only when compared with that made from the Danne-mora ore.

STEEL PLATE ENGRAVING. An entire change in engraving has taken place by the substitution of steel for copper plates. An engraving made upon copper is speedily rendered useless by the process of inking, and the friction necessary to remove the superfluous ink. The rubbing with whitening to clean the face of the plate wears away the surface and renders it valueless after a few thousand impressions.

The Queen's head on the postage stamp has been only once engraved. It had, in 1842, been multiplied 6,000 times, that is to say, the original produced 6,000 plates, which printed all the postage stamps of the above kind which had been used since the introduction of Rowland Hill's measure up to the period stated.

The multiplication of a steel plate is a feature of some importance: a plate is engraved and hardened; from this an impression is taken upon a softened steel roller; this steel roller is then hardened, and softened steel plates being passed under it, an impression is imparted to them; they are then hardened, and are equal to the original as to their impressions. This method is adopted in bank-note engraving; and the postage stamp plates are produced by the same means.

STEREOTYPE PRINTING, signifies printing by fixed types, or by a cast typographic plate. This plate is made as follows:—The form composed in ordinary types, and containing one, two, three, or more pages, inversely as the size of the book, being laid flat upon a slab, with the letters looking upwards, the faces of the types are brushed over with oil, or, preferably, with plumbago (black lead). A heavy brass rectangular frame of three sides, with bevelled borders adapted exactly to the size of the pages, is then laid down upon the chase,* to circumscribe three sides of its typography; but the fourth side, which is one end of the rectangle, is formed by placing near the types, and over the hollows of the chase, a single brass bar, having the same inwards sloping bevel as the other three sides. The complete frame resembles that of a picture, and serves to define the area and thickness of the cast, which is made by pouring the pap of Paris plaster into its interior space, up to a given line on its edges. The plaster mould, which soon sets, or becomes concrete, is lifted gently off the types, and immediately placed upright on its edge in one of the cells of a sheet-iron rack mounted within the cast-iron oven. An able workman will mould ten sheets octavo in a day, or 160 pages. The moulds are here exposed to air heated to fully 400° F., and become perfectly dry in the course of two hours. As they are now friable and porous, they require to be delicately handled. Each mould, containing generally two pages octavo, is laid, with the impression downwards, upon a flat cast-iron plate, called the floating-plate; this plate being itself laid on the bottom of the dipping-pan, which is a cast-iron square tray, with its upright edges sloping outwards. A cast-iron lid is applied to the dipping-pan and secured in its place by a screw. The pan having been heated to 400° in a cell of the oven, under the mould-rack, previous to receiving the hot mould, is ready to be plunged into the bath of melted alloy contained in an iron pot placed over a furnace, and it is dipped with a slight deviation from the horizontal plane, in order to facilitate the escape of the air. As there is a minute space between the back or top surface of the mould and the lid of the dipping-pan, the liquid metal, on entering into the pan through the orifices in its corners, floats up the plaster along with the iron plate on which it had been laid, thence called the floating-plate, whereby it flows freely into every line of the mould, through notches cut in its edge, and forms a layer or lamina upon its face, of a thickness corresponding to the depth of the border. Only a thin metal film is left upon the back of the mould. The dipping-pan is suspended, plunged, and removed by means of a powerful crane, susceptible of vertical and horizontal motions in all directions. When lifted out of the bath, it is set in a water-cistern, upon bearers so placed as to allow its bottom only to touch the surface. Thus the metal first concretes below,

* Chase (*chassis*, frame, Fr.), quoin (*cote*, wedge, Fr.), are terms which show that the art of printing came directly from France to England.

while by remaining fluid above, it continues to impart hydrostatic pressure during the shrinkage attendant upon refrigeration. As it thus progressively contracts in volume, more melted metal is fed into the corners of the pan by a ladle, in order to keep up the hydrostatic pressure upon the mould, and to secure a perfect impression, as well as a solid cast. Were the pan more slowly and equably cooled, by being left in the air, the thin film of metal upon the back of the inverted plaster cake would be apt to solidify first, and intercept the hydrostatic action indispensable to the purpose of filling all the lines in its face. A skilful workman makes five dips, containing two pages octavo each, in the course of an hour, or about nine and a half octavo sheets per day. The pan being taken asunder, the compound cake of mould and metal is removed, and beat upon its edges with a wooden mallet, to detach the superfluous metal. The stereotype plate is then handed over to the picker, who planes its edges truly square, turns its back flat upon a lathe to a determinate thickness, and carefully removes the little imperfections occasioned by dirt or air left among the letters when the mould was cast. Should any of them be damaged in the course of the operation, they must be cut out, and replaced by soldering in separate types of the same size and form.

STEVENSON'S REVOLVING LIGHTHOUSE. This apparatus consists of two parts. The principal part is a right octagonal hollow prism composed of eight large lenses, which throw out a powerful beam of light whenever the axis of a single lens comes in the line between the observer and the focus. This occurs once in a minute, as the frame which bears the lens revolves in eight minutes on the rollers placed beneath. The subsidiary parts consist of eight pyramidal lenses inclined at an angle of 30° to the horizon, and forming together a hollow truncated cone, which rests above the flame like a cap. Above these smaller lenses, (which can only be seen by looking from below) are placed eight plane mirrors, whose surfaces being inclined to the horizon at 50° in the direction opposite to that of the pyramidal lenses, finally cause all the light made parallel by the refraction of these lenses to leave the mirror in a horizontal direction. The only object of this part is to turn to useful account, by prolonging the duration of the flash, that part of the light which would otherwise escape into the atmosphere above the main lenses. This is effected by giving to the upper lenses a slight horizontal divergence from the vertical plane of the principal lenses. Below are five tiers of totally reflecting prisms, which intercept the light that passes below the great lenses, and by means of two reflexions and an intermediate refraction project them in the shape of a flat ring to the horizon.

Fixed dioptric apparatus of the first order (same as that at the Isle of May, with various improvements). The principal part consists of a cylindrical belt of glass which surrounds the flame in the centre, and by its action refracts the light in a vertical direction upward and downward, so as to be parallel with the focal plane of the system. In this way it throws out a flat ring of light equally intense in every direction. To near observers, this action presents a narrow vertical band of light, depending for its breadth on the extent of the horizontal angle embraced by the eye. This arrangement therefore fulfils all the conditions of a fixed light, and surpasses in effect any arrangement of parabolic reflectors. In order to save the light which would be lost in passing above and below the cylindrical belt, curved mirrors with their common focus in the lamp were formerly used; but by the present engineer, the adaptation of *catadioptric* zones to this part of the apparatus was, after much labour, successfully carried out. These zones are triangular, and act by *total* reflexion, the inner face *refracting*, the second *totally reflecting*, and the third or outer face, a second time *refracting*, so as to cause the light to emerge *horizontally*. The apparatus has received many smaller changes by the introduction of a new mode of grouping the various parts of the frame work, by which the passage of the light is less obscured in every azimuth. During the last four years these improvements have been introduced into the lighthouses in Scotland.

Mechanical lamps of four wicks, in which the oil is kept continually overflowing by means of pumps which raise it from the cistern below; the rapid carbonization of the wicks, which would be caused by the great heat, is thus avoided. The flames of the lamp reach their best effect in three hours after lighting, *i. e.* after the whole of the oil in the cistern, by passing and repassing over the wicks repeatedly, has reached its maximum temperature. After this the lamp often burns 14 hours without sensible diminution of the light, and then rapidly falls. The height varies from 16 to 20 times that of the Argand flame of an inch in diameter; and the quantity of oil consumed by it is greater nearly in the same proportion.

Revolving light with axial rotation, by which one half the number of reflectors and one half the quantity of oil are designed to be saved. Intended for illuminating any arch of not more than 180° . The intervals of time of illumination are equal within the whole of the illuminated arch, instead of unequal as in the reciprocating light. The reflectors are also of a new form consisting of parabolic strips of different focal distances.

Ordinary parabolic reflector rendered holophotal, (where the entire light is parallelized) by a portion of a catadioptric annular lens. The back part of the parabolic conoid is cut off, and a portion of a spherical mirror substituted, so as to send the rays again through the flame. All the light intercepted by the annular lens is lost in the ordinary reflector.

Holophotal catadioptric annular lens apparatus (unfinished). This is a combination of a hemispherical mirror, and a lens with totally-reflecting zones; the peculiarity of this arrangement is, that the catadioptric zones, instead of transmitting the light in parallel horizontal plates, as in Fresnel's apparatus, produces, as it were, an extension of the lenticular or quaquaversal action of the central lens by assembling the light around its axis in the form of concentric hollow cylinders. (The above instruments belong to the Board of Northern Lights.)

The early method of illuminating lighthouses was by coal or wood fires contained in "chauffers." The Isle of Man light was of this kind until 1816. The first decided improvement was made by Argand, in 1784, who invented a lamp with a circular wick, the flame being supplied by an external and internal current of air. To make these lamps more effective for lighthouse illumination, and to prevent the ray of light escaping on all sides, a reflector was afterwards added; this threw the light forward in parallel rays towards such points of the horizon as would be useful to the mariner. Good reflectors increase the luminous effect of a lamp about 400 times; this is the "catoptric" system of lighting. When reflectors are used, there is a certain quantity of light lost, and the "dioptric" or *refracting* system, invented by the late M. Augustin Fresnel, is designed to obviate this to some extent: the "catadioptric" system is a still further improvement, and acts both by refraction and reflexion. Lights of the first order have an interior radius or focal distance of 36·22 inches, and are lighted by a lamp of four concentric wicks, consuming 570 gallons of oil per annum.

The appearance of light called short eclipses has hitherto been obtained by the following arrangement:—

An apparatus for a fixed light being provided, composed of a central cylinder and two zones of catadioptric rings forming a cupola and lower part, a certain number of lenses are arranged at equal distances from each other, placed upon an exterior moveable frame making its revolution around the apparatus in a given period. These lenses, composed of vertical prisms, are of the same altitude as the cylinder, and the radius of their curves is in opposite directions to those of the cylinder, in such a manner that at their passage they converge into a parallel pencil of light, all the divergent rays emitted horizontally from the cylinder producing a brilliant effect, like that obtained by the use of annular lenses at the revolving lighthouses.

The first improvement exhibited has special reference to the light, and produces a considerable increase in its power, whilst the simplicity of the optical arrangements is also regarded. It consists, firstly, in completely dispensing with the moveable central cylindrical lenses; secondly, it replaces these by a single revolving cylinder composed of four annular lenses and four lenses of a fixed light introduced between them; but the number of each varying according to the succession of flashes to be produced in the period of revolution.

The second improvement, of which already some applications that have been made serve to show the importance, consists in a new method of arranging the revolving parts, experience having shown that the arrangements at present in use are very faulty. A short time is sufficient for the action of the friction rollers, revolving on two parallel planes, to produce by a succession of cuttings a sufficiently deep groove to destroy the regularity of the rotatory movement. To obviate this great inconvenience the friction rollers are so placed and fitted, on an iron axis with regulating screws and traversing between two bevelled surfaces, that when an indentation is made in one place they can be adjusted to another part of the plates which is not so worn.

The third improvement produces the result of an increase of the power of the flashes in revolving lighthouse apparatus to double what has been obtained hitherto. By means of lenses of vertical prisms placed in the prolongation of the central annular lenses, the divergent rays emerging from the catadioptric zone are brought into a straight line, and a coincidence of the three lenses is obtained.

The whole of the prisms, lenses, and zones are mounted with strength and simplicity, accurately ground and polished to the correct curves according to their respective positions, so as to properly develop the beautiful system of Fresnel. The glass of which they are composed is of the clearest crystal colour, and free from that green hue which so materially reduces the power of the light, and is considered objectionable for apparatus of this kind. The lamp by which the apparatus is to be lighted consists of a concentric burner with four circular wicks attached to a lamp of simple construction, the oil being forced up to the burner by atmospheric pressure only, so that there are no delicate pumps or machinery to become deranged.

Improved lantern and revolving apparatus for a light vessel. The principal improvement consists in constructing the machinery to work beneath the deck, instead of in the lantern as formerly. A vertical rod working in metal bearings is attached to the mast, with a large gun-metal pinion fixed to the top of the rod, at the height to which it is necessary to hoist the lantern, wherein a train of cog wheels is placed, to connect with the pinion and communicate the motion obtained therefrom to the traversing apparatus that supports the lamps and reflectors. The advantages of this arrangement are, that the lanterns can be made much lighter, the rolling of the vessel caused by so great a weight at the mast head is greatly diminished, and the machinery being more under control and better protected, works with greater regularity and precision.

An idea of the utility of these improvements may be gained by reflecting that the situations in which the light-vessels are placed are at all times difficult of access, and in stormy weather, when accidents are most likely to occur, quite unapproachable; so that it will be obvious any alteration which reduces the liability to derangement is greatly to be appreciated.

There is also an advantage derived from the novel construction of the lamps and gimbals, which, by a movement exactly coinciding with the motion of the vessel, causes a perfect level to be always maintained, and ensures the proper flow of oil to the burners, however irregular that motion may be. This improvement is not of so recent an introduction as the former, but when it was first invented by one of the exhibitors, it produced a complete revolution in the apparatus for floating lights, and enabled the beautiful Argand lamps, with parabolic reflectors, to be used instead of the old lamps with smoky flat wicks.

STILL (*Alambic*, Fr.; *Blase*, Germ.): is a chemical apparatus, for vaporizing liquids by heat in one part, called the *cucurbit*, and condensing the vapours into liquids in another part, called the *refrigeratory*; the general purpose of both combined being to separate the more volatile fluid particles from the less volatile. In its simplest form, it consists of a retort and a receiver, or of a pear-shaped matrass and a capital, furnished with a slanting tube for conducting away the condensed vapours in drops; whence the term *still*, from the Latin verb *stillare*, to drop. Its chief employment in this country being to eliminate alcohol, of greater or less strength, from fermented wash, I shall devote this article to a description of the stills best adapted to the manufacture of British spirits, referring to chemical authors* for those fitted for peculiar objects.

In respect of rapidity and extent of work, stills had attained to an extraordinary pitch of perfection in Scotland about forty years ago, when legislative wisdom thought fit to levy the spirits duty, per annum, from each distiller, according to the capacity of his still. It having been shown, in a report presented to the House of Commons in 1799, that an 80-gallon still could be worked off in eight minutes, this fact was made the basis of a new fiscal law, on the supposition that the maximum of velocity had been reached. But, instigated by the hopes of enormous gains at the expense of the revenue, the distillers soon contrived to do the same thing in three minutes, by means of broad-bottomed shallow stills, with stirring-chains, and lofty capitals. In the year 1815, that preposterous law, which encouraged fraud and deteriorated the manufacture, was repealed. The whiskey duties having been since levied, independently of the capacity of the still, upon the quantity produced, such rapid operations have been abandoned, and processes of economy in fuel, and purity in product, have been sought after.

One of the greatest improvements in modern distilleries, is completing the analysis of crude spirit at one operation. Chemists had been long familiar with the contrivance of Woulfe, for impregnating with gaseous matter water contained in a range of bottles; but they had not thought of applying that plan to distillation, when Edouard Adam, an illiterate workman of Montpellier, after hearing accidentally a chemical lecture upon that apparatus, bethought himself of converting it into a still. He caused the boiling hot vapours to chase the spirits successively out of one bottle into another, so as to obtain in the successive vessels alcohol of any desired strength and purity, "*at one and the same heat.*" He obtained a patent for this invention in 1801, and was soon afterwards enabled, by his success on the small scale, to set up in his native city a magnificent distillery, which excited the admiration of all the practical chemists of that day. In November, 1805, he obtained a certificate of certain improvements for extracting from wine, at one process, the whole of its alcohol. Adam was so overjoyed, after making his first experiments, that he ran about the streets of Montpellier, telling every body of the surprising results of his invention. Several competitors soon entered the lists with him, especially Solimani, professor of chemistry in that city, and Isaac

* The treatises of Le Normand and Dubrunfaut may also be consulted. The French stills are in general so much complicated with a great many small pipes and passages, as to be unfit for distilling the glutinous wash of grains.

Berard, distiller in the department of Gard; who, having contrived other forms of continuous stills, divided the profits with the first inventor.

The principles of spirituous distillation may be stated as follows:— The boiling point of alcohol varies with its density or strength, in conformity with the numbers in the following table:—

| Specific gravity. | Boiling point, by Fahrenheit's scale. | Specific gravity. | Boiling point, by Fahrenheit's scale. |
|-------------------|---------------------------------------|-------------------|---------------------------------------|
| 0·7939 | 168·5° | 0·8875 | 181·0° |
| 0·8034 | 168·0 | 0·8631 | 183·0 |
| 0·8118 | 168·5 | 0·8765 | 187·0 |
| 0·8194 | 169·0 | 0·8892 | 190·0 |
| 0·8265 | 172·5 | 0·9013 | 194·0 |
| 0·8332 | 173·5 | 0·9126 | 197·0 |
| 0·8397 | 175·0 | 0·9234 | 199·0 |
| 0·8458 | 177·0 | 0·9335 | 201·0 |
| 0·8518 | 179·0 | | |

See also the table under *АЛКОГОЛ*,

Hence, the lower the temperature of the spirituous vapour which enters the refrigeratory apparatus, the stronger and purer will the condensed spirit be; because the offensive oils, which are present in the wash or wine, are less volatile than alcohol, and are brought over chiefly with the aqueous vapour. A perfect still should, therefore, consist of three distinct members; first, the cucurbit, or kettle; second, the rectifier, for intercepting more or less of the watery and oily particles; and third, the refrigerator, or condenser of the alcoholic vapours.

These principles are illustrated in the construction of the still represented in *figs.* 1365, 1366, 1367, 1368, 1369; in which the resources of the most refined French stills are combined with a simplicity and solidity suited to the grain distilleries of the United Kingdom. Three principal objects are obtained by the arrangement here shown; first, the extraction from fermented wort or wine, at one operation, of a spirit of any desired cleanness and strength; second, great economy of time, labour, and fuel; third, freedom from all danger of blowing up or boiling over, by mismanaged firing. When a combination of water, alcohol, and essential oil, in the state of vapour, is passed upwards through a series of winding passages, maintained at a determinate degree of heat, between 170° and 180°, the alcohol alone, in any notable proportion, will retain the elastic form, and will proceed onwards into the refrigeratory tube, in which the said passages terminate; while the water and the oil will be in a great measure condensed, arrested, and thrown back into the body of the still, to be discharged with the effete residuum.

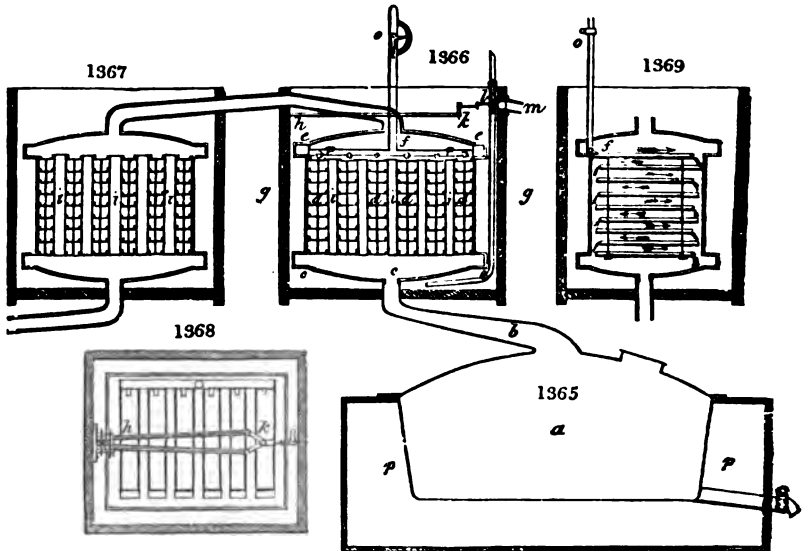
The system of passages or channels, represented in *fig.* 1366, is so contrived as to bring the mingled vapours which rise from the alembic *a*, into ample and intimate contact with metallic surfaces, maintained, in a water-bath, at a temperature self-regulated by a heat-governor. See *ТЪРЪМОСТАТ*.

The neck of the alembic tapers upwards, as shown at *b*, *fig.* 1365; and at *c*, *fig.* 1366, it enters the bottom, or ingress vestibule, of the rectifier *c, f*. *f* is its top or egress vestibule, which communicates with the bottom one by parallel cases or rectangular channels *d, d, d*, of which the width is small, compared with the length and height. These cases are open at top and bottom, where they are soldered or riveted into a general frame within the cavity, enclosed by the two covers *f, c*, which are secured round their edges *e, e, e, e*, with bolts and packing. Each case is occupied with a numerous series of shelves or trays, placed at small distances over each other, in a horizontal or slightly inclined position, of which a side view is given in *fig.* 1367, and cross sections at *d, d, d*, *fig.* 1366. Each shelf is turned up a little at the two edges, and at one end, but sloped down at the other end, that the liquor admitted at the top may be made to flow slowly backwards and forwards in its descent through the system of shelves or trays, as indicated by the darts and spouts in *fig.* 1367. The shelves of each case are framed together by two or more vertical metallic rods, which pass down through them, and are fixed to each shelf by solder, or by screw-nuts. By this means, if the cover *f*, be removed, the sets of shelves may be readily lifted out of the cases and cleaned; for which reason they are called *movable*.

The intervals *i, i, i*, *fig.* 1366, between the cases, are left for the free circulation of the water contained in the bath-vessel *g, g*; these intervals being considerably narrower than the cases.

Fig. 1368, represents in plan the surface of the rectifying cistern, shown in two different sections in *figs.* 1366. and 1367. *h, h*, *figs.* 1366. and 1368., is the heat-governor,

shaped somewhat like a pair of tongs. Each leg is a compound bar, consisting of a flat bar or ruler of steel, and one of brass alloy, riveted facewise together, having their edges up and down. The links, at *k*, are joined to the free ends of these compound bars, which, receding by increase and approaching by decrease of temperature, act by a lever on



the stopcock *l*, fixed to the pipe of a cold-water back, and are so adjusted by a screw-nut, that whenever the water in the bath vessel *g, g*, rises above the desired temperature, cold water will be admitted, through the stopcock *l*, and pipe *m*, into the bottom of the cistern, and will displace the over-heated water by the overflow-pipe *n*. Thus a perfect equilibrium of caloric may be maintained, and alcoholic vapour of correspondent uniformity transmitted to the refrigeratory.

Fig. 1369. is the cold condenser, of similar construction to the rectifier, *fig. 1366.*; only the water cells should be here larger in proportion to the vapour channels *d, d*. This refrigeratory system will be found very powerful, and it presents the great advantage of permitting its interior to be readily inspected and cleansed. It is best made of laminated tin, hardened with a little copper alloy.

The mode of working the preceding apparatus will be understood by the following instructions. Into the alembic, *a*, let as much fermented liquor be admitted as will protect its bottom from being injured by the fire, reserving the main body in the charging-back. Whenever the ebullition in the alembic has raised the temperature of the water-bath *g, g*, to the desired pitch, whether that be 170° , 175° , or 180° , the thermostatic instrument is to be adjusted by its screw-nut, and then the communication with the charging-back is to be opened by moving the index of the stopcock *o*, over a proper portion of its quadrantal arch. The wash will now descend in a slender equable stream, through the pipe *o, f*, thence spread into the horizontal tube *p, p*, and issue from the orifices of distribution, as seen in the figure, into the respective flat trays or spouts. The manner of its progress is seen for one set of trays, in *fig. 1367*. The direction of the stream in each shelf is evidently the reverse of that in the shelf above and below it; the turned-up end of one shelf corresponding to the discharge slope of its neighbour.

By diffusing the cool wash or wine in a thin film over such an ample range of surfaces, the constant tendency of the bath to exceed the proper limit of temperature is counteracted to the utmost, without waste of time or fuel; for the wash itself, *in transitu*, becomes boiling-hot, and experiences a powerful steam distillation. By this arrangement a very moderate influx of cold water, through the thermostatic stopcock, suffices to temper the bath; such an extensive vaporization of the wash producing a far more powerful refrigerant influence than its simple heating to ebullition. It deserves to be remarked, that the maximum distillatory effect, or the bringing over the greatest quantity of pure spirits in the least time, and with the least labour and fuel, is here accomplished without the least steam pressure in the alembic; for the passages are

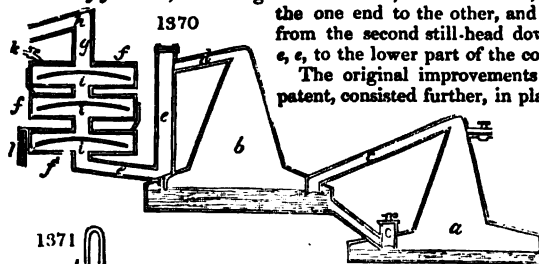
all pervious to the vapour; whereas, in almost every wash-still heretofore contrived for similar purposes, the spirituous vapours must force their way through successive layers of liquid, the total pressure produced by which causes undue elevation of temperature, and obstruction to the process. Whatever supplementary refrigeration of the vapours in their passage through the bath may be deemed proper, will be administered by the thermostatic regulator.

Towards the end of the process, after all the wash has entered the alembic, it may be sometimes desirable, for the sake of despatch, to modify the thermostat, by its adjusting-screw, so that the bath may take a higher temperature, and allow the residuary feints to run rapidly over, into a separate cistern. This weak fluid may be pumped back into the alembic, as the preliminary charge of a fresh operation.

The above plan of a water-bath regulated by the thermostat, may be used simply as a rectifying cistern, without transmitting the spirit or wash down through it. The series of shelves will cause the vapours from the still to impinge against a most extensive system of metallic surfaces, maintained at a steady temperature, whereby their watery and crude constituents will be condensed and thrown back, while their fine alcoholic particles will proceed forwards to the refrigeratory. Any ordinary still may be readily converted into this self-rectifying form, by merely interposing the cistern, *fig.* 1366., between the alembic and the worm-tub. The leading novelty of the present invention is the *movable* system of shelves or trays, enclosed in metallic cases, separated by water, combined with the thermostatic regulator. By this combination, any quality of spirits may be procured at one step from wash or wine, by an apparatus, simple, strong and easily kept in order.

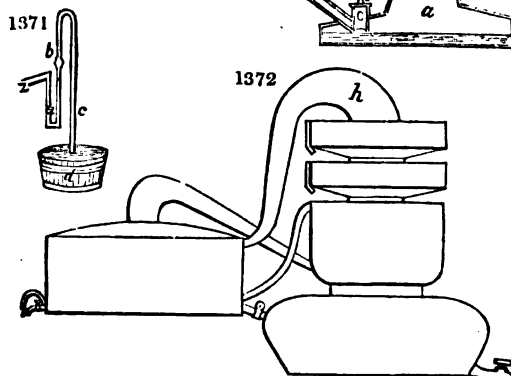
The empyreumatic taint which spirits are apt to contract from the action of the naked fire on the bottom of the still, may be entirely prevented by the use of a bath of potash lye, *p, p, fig.* 1365.; for thus a safe and effectual range of temperature, of 300° F., may be conveniently obtained. The still may also be used without the bath vessel.

Mr. D. T. Shears, of Southwark, obtained a patent in March, 1830, for certain improvements and additions to stills, which are ingenious. They are founded upon a previous patent, granted to Joseph Corty, in 1818; a section of whose contrivance is shown in *fig.* 1370., consisting of a first still *a*, a second still *b*, a connecting tube *c*, from



the one end to the other, and the tube *d*, which leads from the second still-head down through the bent tube *e, e*, to the lower part of the condensing apparatus.

The original improvements described under Corty's patent, consisted further, in placing boxes *f, f, f*, of the



condensing apparatus in horizontal positions, and at a distance from each other, in order that the vapour might ascend through them, for the purpose of discharging the spirit by the top tube *g*, and pipe *h*, into the worm, in a highly rectified or concentrated state. In each of the boxes *f*, there is a convex plate or inverted dish *i, i, i*, and the vapour in rising from the tube *e*, strikes against the concave or under part of the first dish, and then escapes round its edges, and over its convex surface, to the under part of the second dish, and so on to the top, the

condensed part of the vapour flowing down again into the still, and the spirit passing off by the pipe *h*, at top; and as the process of condensation will be assisted by cooling the vapour as it rises, cold water is made to flow over the tops of the boxes *f*, from a cock *k*, and through small channels or tubes on the sides of the boxes, and is ultimately discharged by the pipe *l*, at bottom.

Fig. 1371. represents a peculiarly shaped tube *a*, through which the spirit is described as passing after leaving the end of the worm at *b*, which tube is open to the atmosphere

air at *z*; *c*, is the passage through which the carbonic acid gas is described as escaping into the vessel of water *d*.

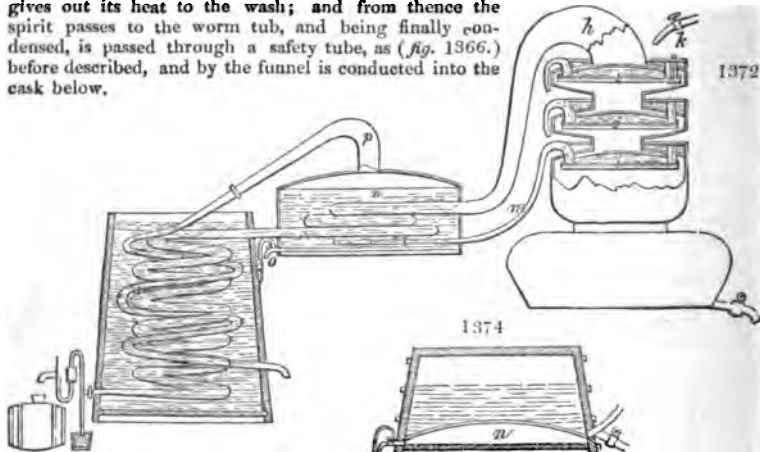
Now the improvements claimed under the present patent, are exhibited in *figs.* 1372, 1373, and 1374. *Fig.* 1372. represents the external appearance of a still, the head of which is made very capacious, to guard against over-boiling by any mismanagement of the fire; *fig.* 1373. is the same, partly in section. On the top of the still-head is formed the first-described rectifying apparatus, or series of condensing boxes. The vapour from the body of the still filling the head, meets with the first check from the dish or lower vessel *i*, and after passing under its edges, ascends and strikes against the lower part of the second dish or vessel *i*, and so on, till it ultimately leaves the still-head by the pipe at top.

This part of the apparatus is slightly altered from the former, by the substitution of hollow convex vessels, instead of the inverted dishes before described, which vessels have rims descending from their under surfaces, for the purpose of retaining the vapour. The cold water, which, as above described, flowed over the tops of the boxes *f*, for the purpose of cooling them, now flows also through the hollow convex vessels *i*, within the boxes, and by that means greatly assists the refrigerating process, by which the aqueous parts of the vapour are more readily condensed, and made to fall down and flow back again into the body of the still, while the spirituous parts pass off at top to the worm, in a very high state of rectification.

After the water employed for the refrigeration has passed over all the boxes, and through all the vessels, it is carried off by the pipe *m*, through the vessel *n*, called the wash-heater; that is, the vessel in which the wash is placed previous to introducing it into the still. The pipe *m*, is coiled round in the lower part of the vessel *n*, in order that the heated water may communicate its caloric to the wash, instead of losing the heat by allowing the water to flow away. After the heated water has made several turns round the wash heater, it passes out at the curved pipe *o*, which is bent up, in order to keep the coils of the pipe within always full of water.

Instead of the coiled pipe *n*, last described, the patentee proposes sometimes to pass the hot water into a chamber in a tub or wooden vessel, as at *n*, in *fig.* 1369., in which the wash to be heated occupies the upper part of the vessel, and is separated from the lower part by a thin metallic partition.

The swan-neck *h*, *figs.* 1372. and 1373., which leads from the head of the still, conducts the spirit from the still through the wash-heater, where it becomes partially cooled, and gives out its heat to the wash; and from thence the spirit passes to the worm tub, and being finally condensed, is passed through a safety tube, as (*fig.* 1366.) before described, and by the funnel is conducted into the cask below.



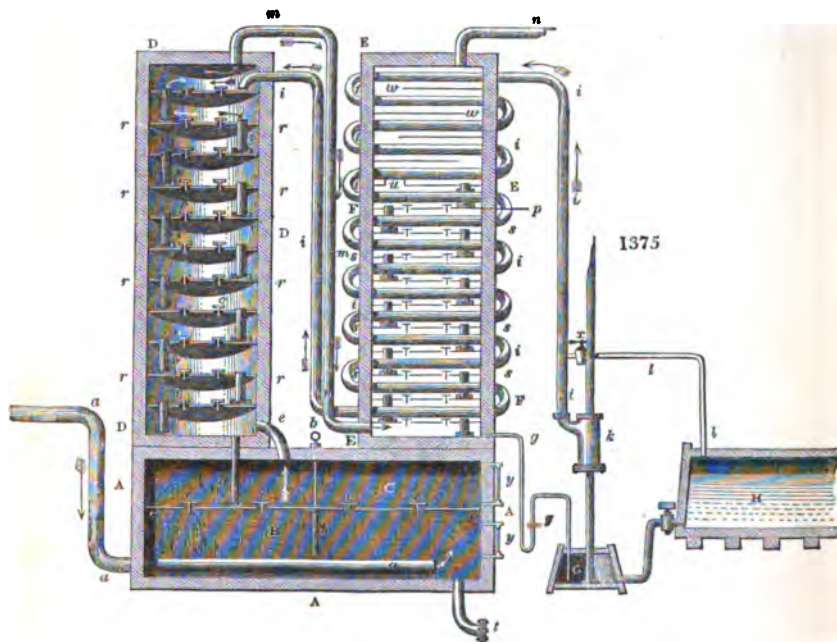
Should any spirit rise in the wash-heater during the above operation, it will be carried down to the worm by the neck *p*, and coiled pipe, and discharged at its lower end; or it may be passed into the still-head, as shown in *fig.* 1370.

Coffey's Still This ingenious, original, and powerful apparatus for distilling spirits from fermented worts or wash of all kinds, is, after many struggles with the illiberal prejudices of the Excise, now universally recognized as the best, most economical, and surest in a revenue point of view, of all the contrivances of eliminating the alcohol, in the purest state, and of any desired strength, at one operation. Its outer form and internal structure differ essentially from those of all the old stills, though it possesses some of the good principles of Derosnes, in continuity of action, and in causing a current

of spirituous vapour to ascend, and a current of wash deprived of its alcohol to descend in one system of continuous cells. Its main structure consists of a series of wooden planks, 5 or 6 inches thick, fixed over one another, the joints being covered, or the whole being lined with sheet copper; so that the apparatus resembles a great chest, to which is attached the induction pipe of a steam boiler, as the active principle of the whole.

The essential apparatus consists of three main parts; the wash collector Λ , Λ , and the two rectangular columns or uprights.

The front column \mathfrak{D} , \mathfrak{D} , or the analyser, is for rectifying the wash, the other column is intended for warming the wash; the under part \mathfrak{F} , \mathfrak{F} , of the forewarmer serves as a dephlegmator and for the rectification of the feints; the upper part \mathfrak{E} , \mathfrak{E} , serves to condense the strong spirituous vapour.



The wash collector Λ , is divided into two compartments b and c , by means of the copper plate cc ; this plate cc , is pierced like a drainer, with a number of small holes, and is provided also with a τ shaped valve ooo . The wash rectifier \mathfrak{D} is divided by the plates r, r , of a like drainer construction into 12 chambers, and the feint rectifier \mathfrak{F} , into 10 chambers by similar plates s, s, s . These orifices are so narrow as to allow the passage of the rising vapour, but to prevent the downward passage of the liquid resting on the plates, which passes downwards through the adjunct tubes, viz. d , into the wash collector Λ , v , into the rectifier \mathfrak{D} , and likewise into the dephlegmator \mathfrak{F} , passing from each upper into the next under chamber. When the steam pressure is too strong, the valves o, o give it vent.

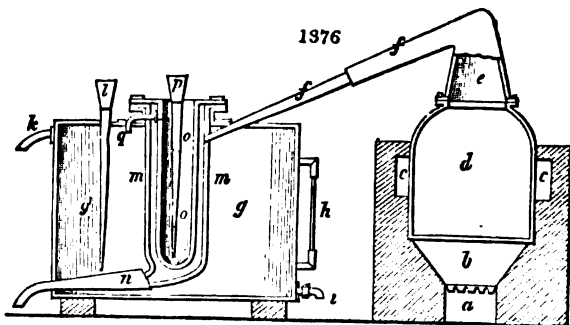
When the apparatus is in action, a continuous stream of wash is raised out of a , by means of the pump k , into the tube i , which feeds the still. This current must be regulated very nicely, so as just to feed the tube i , allowing the excess to return through the stop-cock x , and the tube l , into the wash cistern u . The tube i enters into the uppermost partition of \mathfrak{E} , forming 7 zig-zag bendings in this space, and through r , and then mounts upwards from that chamber into the top chamber of \mathfrak{D} . Thence the wash flows down from chamber to chamber, and arrives through d into c , and finally in a similar way into b , where it is fully deprived of spirit, and is from time to time run off through t . It is necessary throughout that the wash in this passage into \mathfrak{D} and Λ should stand about an inch high upon each plate r, r , for which purpose the adjunct tubes v

should stand an inch above the plate, and thus give the vapour no indirect passage, as the under end of each tube v dips into a shallow cup, and is thus shut in by the wash remaining in it. The tube d , which leads the wash from the plate cc into c , serves a like purpose. As soon as it has risen up in it to the upper orifice of the glass tube y , the valve b is to be opened, to allow it to flow off into s through the tube δ .

Here into s the very hot and nearly spent wash comes into contact with the steam issuing from the steam boiler through the steam tube a, a . It rushes through it, and carries off from it the spirit through the small orifices of the plate c , expands thus into the whole breadth of this chamber through the wash standing in it, and deprives this at once of every trace of spirit, then collects over the fluid, and enters through the connection tube e , into the undermost chamber of n , and thence into the following in succession, always through the orifices of the plate r, r . Whilst the steam meets the wash in every chamber, and becomes more spirituous the higher it mounts, it at the same time becomes cooler, and deposits the watery part, absorbing more alcohol, so that after this complicated rectification it passes on through the tube m, m , into the lowest chamber of the forewarmer r . It here pursues a like path upwards through the plates s, s , where the feints are at the same time rectified by the dephlegmation of the vapour. The steam flows through the different junction tubes into r , and its subdivisions, whereby (as the wash in n) forms upon each plate a layer an inch thick to be penetrated by the steam. The remainder passes out of the undermost plate through the tube gg , into o , where it is carried on by the pump with fresh wash into circulation in the apparatus.

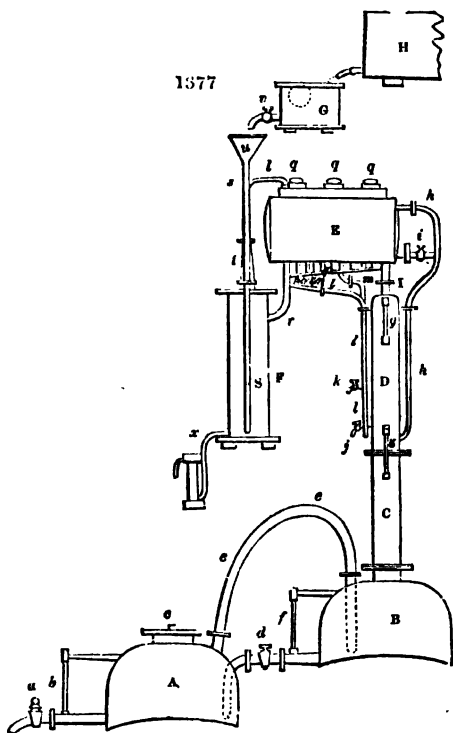
The alcoholic vapour reaches now x . The plate which separates x and r is not perforated; it lets the vapour merely pass through the short and wide junction tube x , into the condenser x , where in like manner the non-perforated plates w, w , compel it to follow the zig-zag bendings of i, i , so as to complete its condensation and the heating of the wash in r . The completely condensed vapour is collected on the bottom of x , and is conducted out of the cup of the junction tube there, (which is larger) through the annexed tube sideways at p , into the refrigerator, (not shown in the figure).

I shall conclude this article with a description of two stills, the first of which is commonly employed by the chemists in Berlin for rectifying alcohol. a , is the ash-pit; b



the fireplace; c, c , the flues, which go spirally round the sides of the cucurbit d ; e , the capital, made of block tin, and furnished with a brass edge, which fits tight to a corresponding edge on the mouth of d ; f, f , the slanting pipes of the capital; g , the oval refrigerator, made of copper; h , the water-gauge glass tube; t , a stopcock for emptying the vessel; k, k , do, for drawing off the hot water from the surface; l , tube for the supply of cold water. A double cylinder of tin is placed in the refrigerator, of which the outer one m, m , stands upon three feet, and is furnished with a discharge pipe p , and lets the warm water flow off through the short tube g , into the refrigerator. In the narrow space between the two cylinders, the vapours preceeding from the capital are condensed, and pass off in the liquid state through x . The refrigerator is made oval, in order to receive two condensers alongside of each other in the line of the longer axis; though only one, and that in the middle, is represented in the figure.

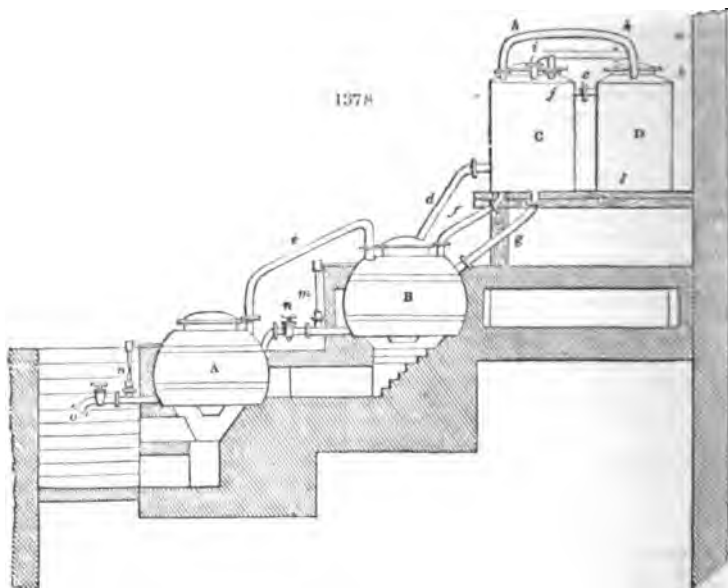
The continuous system of distillation has been carried in France to a great pitch of perfection, by the ingenuity chiefly of M. Cellier Blumenthal, and M. Ch. Derome. Fig. 1377, is a general view of their apparatus; a and b are boilers or alembics encased



the vinasse from the lower part of the wine-heater, *x*, upon the uppermost of the series of horizontal discs, mounted within the column of distillation; *i*, a stop-cock for emptying the wine-heater at the end of an operation; *l, l*, two tubes fitted to the wine-heater, *x*, of which the first descends into the last compartment of the rectifier, whence it rises to the fifth; and the second tube descends to the third compartment, whence it rises above the second. At the curvature of each of these two tubes a stopcock, *l* and *k*, is placed on them, for drawing at pleasure a sample of the liquor returned to the rectifier; *m, n*, and *o*, are tubes communicating on one side with the slanting tube, *p*, and on the other with the tube, *l*. These three communications serve to furnish a spirit of greater or less strength. Thus if it be wished to obtain a very strong spirit, the alcoholic vapours which condense in the worm enclosed in *x*, are all to be led back into the rectifier, *D*, to effect which purpose it is requisite merely to open the stop-cocks, *n* and *o*; again, weaker spirits may be had by closing the stop-cock, *o*, and still weaker by closing the stop-cock, *n*; for in this case, the alcoholic vapours condensed in the worm within *x*, will flow off into the worm within the upright cooler, *r*, and will get mixed with the richer vapours condensed in this refrigeratory. The interior of the column, *C*, contains a series of movable concave scale pans (like those of balances), with spaces between, each alternate pan having the convex side turned reversely of the preceding one, for the purpose of prolonging the cascade descent of the vinasse through *C*, and exposing it more to the heating action of the ascending vapours; the edges of these pans are, moreover, furnished with projecting spiculae of copper wires, to lead off the liquor from their surfaces in a fine shower. The interior of the rectifier column, *D*, is mounted with a series of shelves, or floors, the passage from one compartment to that above it being through a short tube, bent at right angles, and open at either end; *p, p, p*, is a general tube, for receiving the vapours condensed in each of the turns of the large serpentine within *x*. The axis of this worm is horizontal; *q, q, q*, peep-holes in the top of the wine-heater; *r*, a tube to conduct the alcoholic vapours not condensed in the worm of *x*, and also, if desired, those which have been condensed there, into the worm of the refrigeratory, *r*; *s*, a tube to bring the vinasse from the reservoir, *G*, into the lower part

of the cooler, *r*; *l*, a tube to lead the vinasse from the upper part of the cooler, *r*, into the upper part of the wine-heater, *z*; *u*, a funnel; *v*, a stop-cock to feed the tube, *l*, with vinasse; *x*, a tube of outlet for the spirits produced; it ends, as shown in the figure, in a test tube containing an hydrometer.

The still of Laugier is represented by a general view in *fig. 1378*. *A* and *B* are alembics



exposed to the direct action of the fire, and serve a like purpose to those of *fig. 1377*; *C*, is a cylinder containing the rectifier, and serving as a wine-heater; *D*, is the condensing cylinder; *a*, a stop-cock communicating with the wine tun; *b*, a plunger-tube, furnished with a funnel, through which wine runs constantly into the condenser, *D*; *c*, an overflow pipe of *D*, between *c* and *D*, communicating by a tube, dipping in the cylinder, *c*; *d*, a plunger equilibrium tube, supplying the alembics with hot wine; *e*, a tube leading the vapours of the first alembic, *A*, into the second one, *B*, into which it dips; *f*, a tube conducting the vapours of alcohol from the alembic, *B*, into the circles of the rectifier; *g*, a tube bringing back into the alembic, *B*, the vapours condensed in the circles of the rectifier; *h*, a tube conducting the vapours not condensed into the worm of the condenser; *i*, a tube serving for the expulsion of the air when the wine comes into the vessel *c*; it communicates with the tube, *h*, so as not to lose alcohol. *j*, is a prolongation of the tube *D*, communicating with the tube *h*, so that it may be in contact with the external air; *l*, a stop-cock through which the alcohol condensed runs off into the serpentine; *m*, levels, indicating the height of the liquor in the alembics, *A* and *B*; *n*, tube with a stop-cock, for feeding the alembic *A*; *o*, a discharge stop-cock of the spent vinasse (wash).

A description of the operation of the first still will render that of the second intelligible.

The alembic, *A*, being filled three-fourths with vinasse, and a having only 4 or 5 inches of vinasse over its bottom, the liquor in *A* is made to boil, and the stop-cock, *r*, being at the same time opened, some of the wine to be distilled is allowed to fall into the funnel, *u*; this cold liquor runs to the bottom of the cooler, *r*, fills it, passes into the wine-heater by the tube, *l*, spreads into a perforated conduit along the top of *z*, thence trickles down into this vessel till it fills it to the level of the tube, *h*, by which it is conducted into the column, *c*, and, flowing down through all its compartments, it falls at last into the second alembic, *B*.

During this progress, the liquor of *A* having begun to boil, the alcoholic vapour passes, by means of the tube *e*, into the second alembic *B*, which, being heated by these vapours, and by the products of combustion issuing from the fire-place under the first alembic, is also soon made to boil. The vapour which it produces is disengaged into the column of distillation *c*, meets there the wine which trickles through all its compartments transfers to it a portion of its heat, and deprives it of alcohol, goes into the

column *n*, where it is alcoholized afresh, then enters into the worm within the wine-heater *x*, glides through all its windings, gets stripped in part of the aqueous vapours which accompanied the alcohol, and which return first by the tube *p, p*, then by *l, l*, into the column of rectification: afterwards the spirituous vapour passes into the worm enclosed in the cooler *r*, to issue finally condensed and deprived of all the water, wished to be taken from it, by the tube *x*, into the gauge receiver.

When the indicator *f*, of the alembic *a*, shows it to be nearly full, the stop-cock *a* of the alembic *a* is opened, and the vinasse is allowed to run out entirely exhausted of spirit; but as soon as there are only seven inches of liquor above the discharge pipe, the cock *a* is shut, and *d* is opened to run off seven inches of liquor from *a*.

It appears, therefore, that in reference to the discharge, the operation is not quite continuous; but this slight interruption is a real improvement introduced by M. Derosne into the working of M. Blumenthal's apparatus. It is impossible for any distiller, however expert, to exhaust entirely the liquor of the last alembic, if the discharge be not stopped for a short time. The above distilling apparatus requires from two to three hours to put it in full action. From 10 to 15 per cent. of spirit of $\frac{3}{4}$ are obtained from the average of French wine! and 600 litres of such spirit are run off with 1.50 kilogrammes of coals; or about two old English quarts of spirit for each pound of coals.

STOCKING MANUFACTURE. See HOBIERY.

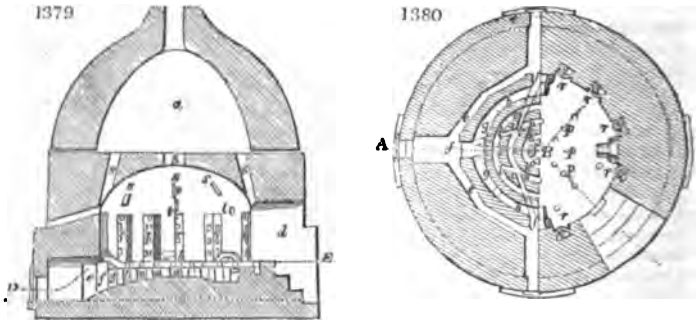
STONE, is earthy matter, condensed into so hard a state as to yield only to the blows of a hammer, and therefore well adapted to the purposes of building. Such was the care of the ancients to provide strong and durable materials for their public edifices, that but for the desolating hands of modern barbarians, in peace and in war, most of the temples and other public monuments of Greece and of Rome would have remained perfect at the present day, uninjured by the elements during 2000 years. The contrast, in this respect, of the works of modern architects, especially in Great Britain, is very humiliating to those who boast so loudly of social advancement; for there is scarcely a public building of recent date which will be in existence one thousand years hence. Many of the most splendid works of modern architecture are hastening to decay, in what may be justly called the very infancy of their existence, if compared with the date of those erected in ancient Italy, Greece, and Egypt. This is remarkably the case with the three bridges of London, Westminster, and Blackfriars; the foundations of which began to perish most visibly in the very lifetime of their constructors. Every stone intended for a durable edifice ought to be tested as to its durability, by immersion in a saturated solution of sulphate of soda, and exposure during some days to the air. The crystallization which ensues in its interior will cause the same disintegration of its substance which frost would occasion in a series of years.

STONES, for building, and bricks, may be proved as to their power of resisting the action of frost, by the above method, first practised by M. Brard, and afterwards by MM. Vicat, Billaudel, and Coarad, engineers of the bridges and highways in France. The operation of water in congealing within the pores of a stone may be imitated by the action of a salt, which can increase in bulk by a cause easily produced; such as efflorescence or crystallization, for example. Sulphate of soda or Glauber's salt answers the purpose perfectly, and it should be applied as follows:—

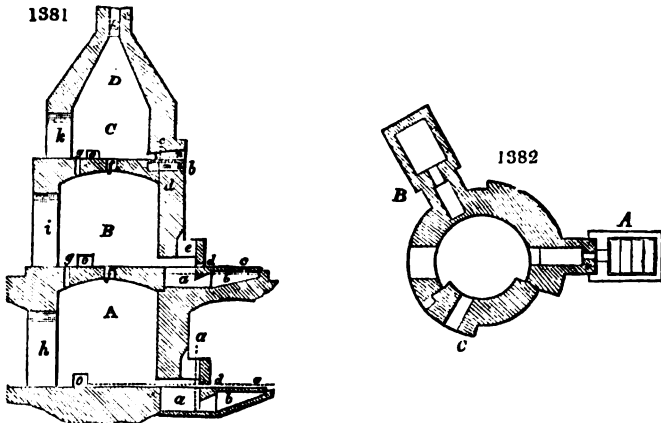
Average samples of the stones in their sound state, free from shakes, should be sawed into pieces 2 or 3 inches cube, and numbered with China ink or a graving tool. A large quantity of Glauber's salt should be dissolved in hot water, and the solution should be left to cool. The clear saturated solution being heated to the boiling point in a saucepan, the several pieces of stone are to be suspended by a thread in the liquid for exactly one half-hour. They are then removed and hung up each by itself over a vessel containing some of the above cold saturated solution. In the course of 24 hours, if the air be not very damp or cold, a white efflorescence will appear upon the stones. Each piece must be then immersed in the liquor in the subjacent vessel, so as to cause the crystals to disappear, be once more hung up—and dipped again whenever the dry efflorescence forms. The temperature of the apartment should be kept as uniform as possible during the progress of the trials. According to their tendency to exfoliate by frost, the several stones will show, even in the course of the first day, alterations on the edges and angles of the cubes; and in 5 days after efflorescence begins, the results will be manifest, and may be estimated by the weight of disintegrated fragments, compared to the known weight of the piece in its original state, both taken equally dry.

STONE, ARTIFICIAL, for statuary and other decorations of architecture, has been made for several years with singular success at Berlin, by Mr. Feilner. His materials are nearly the same with those of English pottery; and the plastic mass is fashioned either in moulds, or by hand. His kilns, which are peculiar in form, and economical in fuel, deserve to be generally known. *Figs.* 1379. and 1380. represent his round kiln; *fig.* 1379. being an oblique section in the line *a, a, c*, of *fig.* 1380, which is

a ground plan in the line *d, a, b, x*, of *fig. 1379*. The inner circular space *c*, covered with the elliptical arch, is filled with the figures to be baked, set upon brick supports. The hearth is a few feet above the ground; and there are steps before the door *d*, for the workmen to mount by, in charging the kiln. The fire is applied on the four sides under the hearth. The flame of each passes along the straight flues *f i, f i*, and *f k*. In the second annular flue *g, g*, as also in the third *l, l*, the flame of each fire is kept apart, being separated from the adjoining, by the stones *k* and *m*. In the fourth flue *n*, the flames again come together, as also in *o*, and ascend by the middle opening. Besides this large orifice, there are several small holes, *p, p*, in the hearth over the above flues, to lead the flames from the other points into contact with the various articles. There are also channels *q, q*, in the sides, enclosed by thin walls *r*, to promote the equable distribution of the heat; and these are placed right over the first fire-flues *e*. The partitions *r*, are perforated with many holes, through which, as well as from their tops, the flame may be directed inwards and downwards; *s* are the vents for carrying off the



flames into the upper space *n*, which is usually left empty. These vents can be closed by iron damper-plates, pushed in through the slide-slits of the dome. *t, t*, are peep-holes, for observing the state of ignition in the furnace; but they are most commonly bricked up. *Fig. 1381*, is a vertical section, and *fig. 1382*, a plan, of an excellent kiln for baking clay to a stony consistence, for the above purpose, or for burning fire-bricks.



A, is the lower; *B*, the middle; *C*, the upper kiln; and *D*, the hood, terminating in the chimney *x*. *a, a*, is the ash-pit; *b, b*, the vault for raking out the ashes; it is covered with an iron door *c*. *d*, is the peep-hole, filled with a clay stopper; *e*, is the fire-place; *f, f*, a vent in the middle of each arch; *g, g*, flues at the sides of the arches, situated between the two fireplaces; *h, i, k*, are apertures for introducing the articles to be baked; *l*, a grate for the fire in the uppermost kiln; *m*, the ash-pit; *n*, the fire-door; *o*, openings through which the flames of a second fire are thrown in. At first, only the ground kiln *A* is fired, with cleft billets of pine-wood, introduced at the opening *e*; when this

is finished, the second is fired; and then the third, in like manner. This kiln is very like the porcelain kiln of Sèvres, and is employed in many places for baking stoneware.

Mr. Keene obtained a patent a few years ago, for making a factitious stone-paste in the following way:— He dissolves one pound of alum in a gallon of water, and in this solution he soaks 84 pounds of gypsum calcined in small lumps. He exposes these lumps in the open air for about eight days, till they become apparently dry, and then calcines them in an oven at a dull-red heat. The waste heat of a coke oven is well adapted for this purpose. (See *PRCOAL, COKING OF.*) These lumps, being ground and sifted, afford a fine powder, which, when made up into a paste with the proper quantity of water, forms the petrifying ground. The mass soon concretes, and after being brushed over with a thin layer of the petrifying paste, may be polished with pumice, &c., in the usual way. It then affords a body of great compactness and durability. If half a pound of copperas be added to the solution of the alum, the gypsum paste, treated as above, has a fine cream or yellow colour. This stone stands the weather tolerably well.

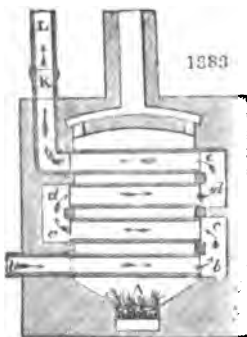
STONEWARE. (*Fayence*, Fr.; *Steingut*, Germ.) See **PORCELAIN**.

STORAX, STYRAX, flows from the twigs and the trunk of the *Liquidamber styraciflua*, a tree which grows in Louisiana, Virginia, and Mexico. Liquidamber, as this resin is also called, is a brown or ash-gray substance, of the consistence of turpentine, which dries up rapidly, has an agreeable smell, like benzoin, and a bitterish, sharp, burning taste. It dissolves in four parts of alcohol, and affords 1·4 per cent. of benzoic acid.

STOVE (*Pöele*, *Calorifère*, Fr.; *Ofen*, Germ.); is a fireplace, more or less close, for warming apartments. When it allows the burning coals to be seen, it is called a stove-grate. Hitherto stoves have rarely been had recourse to in this country for heating our sitting-rooms; the cheerful blaze and ventilation of an open fire being generally preferred. But last winter but two, by its inclemency, gave birth to a vast multitude of projects for increasing warmth and economizing fuel, many of them eminently insalubrious, by preventing due renewal of the air, and by the introduction of noxious fumes into it. When coke is burned very slowly in an iron box, the carbonic acid gas which is generated, being half as heavy again as the atmospherical air, cannot ascend in the chimney at the temperature of 300° F.; but regurgitates into the apartment through every pore of the stoves, and poisons the atmosphere. The large stoneware stoves of France and Germany are free from this vice; because, being fed with fuel from the outside, they cannot produce a reflux of carbonic acid into the apartment, when their draught becomes feeble, as inevitably results from the obscurely burning stoves which have the doors of the fireplace and ash-pit immediately above the hearth-stone.

I have recently performed some careful experiments upon this subject, and find that when the fuel is burning so slowly in the stoves as not to heat the iron surface above the 250th or 300th degree of Fahr., there is a constant deflux of carbonic acid gas from the ash-pit into the room. This noxious emanation is most easily evinced by applying the beak of a matrass, containing a little Goulard's extract (solution of sub-acetate of lead), to a round hole in the door of the ash-pit of a stove in this languid state of combustion. In a few seconds the liquid will become milky, by the reception of carbonic acid gas. I shall be happy to afford ocular demonstration of this fact to any incredulous votary of the pseudo-economical, anti-ventilation, stoves now so much in vogue. There is no mode in which the health and life of a person can be placed in more insidious jeopardy, than by sitting in a room with its chimney closed up with such a choke-damp-venting stove.

That fuel may be consumed by an obscure species of combustion, with the emission of very little heat, was clearly shown in Sir H. Davy's *Researches on Flame*. "The facts detailed on insensible combustion," says he, "explain why so much more heat is obtained from fuel when it is burned quickly, than slowly; and they show that, in all cases, the temperature of the acting bodies should be kept as high as possible; not only because the general increment of heat is greater, but likewise because those combinations are prevented, which, at lower temperatures, take place without any considerable production of heat. These facts likewise indicate the source of the great error into which experimenters have fallen, in estimating the heat given out in the combustion of charcoal; and they indicate methods by which the temperature may be increased, and the limits to certain methods." These conclusions are placed in a strong practical light by the following simple experiments:— I set upon the top orifice of a small cylindrical stove, a hemispherical copper pan, containing six pounds of water, at 60° F., and burned briskly under it 3½ pounds of coke in an hour; at the end of which time, 4½ pounds of water were boiled off. On burning the same weight of coke *slowly* in the same furnace, surmounted by the same pan, in the course of 12 hours, little more than one-half the quantity of water was exhaled. Yet, in the first case, the aerial products of combustion swept so rapidly over the bottom of the

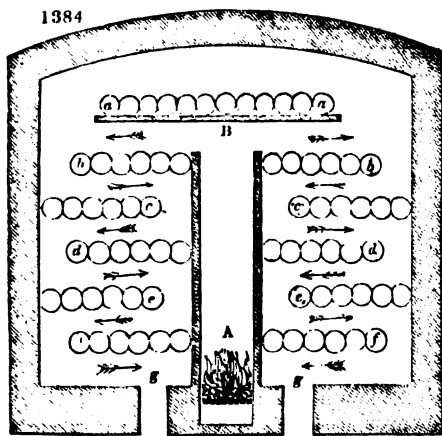


pan, as to communicate to it not more than one-fourth of the effective heat which might have been obtained by one of the plans described in the article *EVAPORATION*; while, in the second case, these products moved at least 12 times more slowly across the bottom of the pan, and ought therefore to have been so much the more effective in evaporation, had they possessed the same power or quantity of heat.

Stoves, when properly constructed, may be employed both safely and advantageously to heat entrance-halls upon the ground story of a house; but care should be taken not to vitiate the air by passing it over ignited surfaces, as is the case with most of the patent stoves now foisted upon the public. *Fig. 1383.* exhibits a vertical section of a stove which has been recommended for power and economy; but it is highly objectionable, as being apt to scorch the air.

The flame of the fire *A*, circulates round the horizontal pipes of cast iron, *b b, c c, d d, e e*, which receive the external air at the orifice *k*, and conduct it up through the series, till it issues highly heated at *x, l*, and may be thence conducted wherever it is wanted. The smoke escapes through the chimney *B*. This stove has evidently two prominent faults; first, it heats the air-pipes very unequally, and the undermost far too much; secondly, the air, by the time it has ascended through the zigzag range to the pipe *e e*, will be nearly of the same temperature with it, and will therefore abstract none of its heat. Thus the upper pipes, if there be several in the range, will be quite inoperative, wasting their warmth upon the sooty air.

Fig. 1384. exhibits a transverse vertical section of a far more economical and powerful stove, in which the above evils are avoided. The products of combustion of the fire *A*,



rise up between two brick walls, so as to play upon the bed of tiles *x*, where, after communicating a moderate heat to the series of slanting pipes whose areas are represented by the small circles *a, a*, they turn to the right and left, and circulate round the successive rows of pipes *b, b, c, c, d, d, e, e*, and finally escape at the bottom by the flues *g, g*, pursuing a somewhat similar path to that of the burned air among a bench of gas-light retorts. It is known, that two-thirds of the fuel have been saved in the gas-works by this distribution of the furnace. For the purpose of heating apartments, the great object is to supply a vast body of genial air; and, therefore, merely such a moderate fire should be kept up in *A*, as will suffice to warm all the pipes pretty equally to

the temperature of 220° Fahr.; and, indeed, as they are laid with a slight slope, are open to the air at their under ends, and terminate at the upper in a common main pipe or tunnel, they can hardly be rendered very hot by any intemperance of firing. I can safely recommend this stove to my readers. If the tubes be made of stoneware, its construction will cost very little; and they may be made of any size, and multiplied so as to carry off the whole effective heat of the fuel, leaving merely so much of it in the burned air, as to waft it fairly up the chimney.

I shall conclude this article by a short extract of a paper which was read before the Royal Society, on the 16th of June, 1836, upon *warming and ventilating apartments*; a subject to which my mind had been particularly turned at that time, by the Directors of the Customs Fund of Life Assurance, on account of the very general state of indisposition and disease prevailing among those of their officers (nearly 100 in number) engaged on duty in the Long Room of the Custom House, London.

"The symptoms of disorder experienced by the several gentlemen (about twenty in number), whom I examined, out of a great many who were indisposed, were of a very uniform character. The following is the result of my researches:—

"A sense of tension or fulness of the head, with occasional flushings of the countenance, throbbing of the temples, and vertigo, followed, not unfrequently, with a con-

fusion of ideas, very disagreeable to officers occupied with important and sometimes intricate calculations. A few are affected with unpleasant perspiration on their sides. The whole of them complain of a remarkable coldness and languor in their extremities, more especially the legs and feet, which has become habitual, denoting languid circulation in these parts, which requires to be counteracted by the application of warm flannels on going to bed. The pulse is, in many instances, more feeble, frequent, sharp, and irritable, than it ought to be, according to the natural constitution of the individuals. The sensations in the head occasionally rise to such a height, notwithstanding the most temperate regimen of life, as to require cupping, and at other times depletory remedies. Costiveness, though not a uniform, is yet a prevailing symptom.

"The sameness of the above ailments, in upwards of one hundred gentlemen, at very various periods of life, and of various temperaments, indicates clearly sameness in the cause.

"The temperature of the air in the Long Room ranged, in the three days of my experimental inquiry, from 62° to 64° of Fahrenheit's scale; and in the Examiner's Room it was about 60° , being kept somewhat lower by the occasional shutting of the hot-air valve, which is here placed under the control of the gentlemen; whereas that of the Long Room is designed to be regulated in the sunk story, by the fireman of the stove, who seems sufficiently careful to maintain an equable temperature amidst all the vicissitudes of our winter weather. Upon the 7th of January, the temperature of the open air was 50° ; and on the 11th it was only 35° ; yet upon both days the thermometer in the Long Room indicated the same heat, of from 62° to 64° .

"The hot air discharged from the two cylindrical stove-tunnels into the Long Room was at 90° upon the 7th, and at 110° upon the 11th. This air is diluted, however, and disguised, by admixture with a column of cold air, before it is allowed to escape. The air, on the contrary, which heats the Examiner's Room, undergoes no such mollification, and comes forth at once in an ardent blast of fully 170° ; not unlike the simoom of the desert, as described by travellers. Had a similar nuisance, on the greater scale, existed in the Long Room, it could not have been endured by the merchants and other visitors on business: but the disguise of an evil is a very different thing from its removal. The direct air of the stove, as it enters the Examiner's Room, possesses, in an eminent degree, the disagreeable smell and flavour imparted to air by the action of red-hot iron; and, in spite of every attention on the part of the fireman to sweep the stove apparatus from time to time, it carries along with it abundance of burned dusty particles.

"The leading characteristic of the air in these two rooms, is its dryness and disagreeable smell. In the Long Room, upon the 11th, the air indicated, by Daniell's hygrometer, 70 per cent. of dryness, while the external atmosphere was nearly saturated with moisture. The thermometer connected with the dark bulb of that instrument stood at 30° when dew began to be deposited upon it; while the thermometer in the air stood at 64° . In the court behind the Custom-house, the external air being at 35° , dew was deposited on the dark bulb of the hygrometer by a depression of only 3° ; whereas in the Long Room, on the same day, a depression of 34° was required to produce that deposition. Air, in such a dry state, would evaporate 0.44 inches depth of water from a cistern in the course of twenty-four hours; and its influence on the cutaneous exhalents must be proportionably great.

"As cast iron always contains, besides the metal itself, more or less carbon, sulphur, phosphorus, or even arsenic, it is possible that the smell of air passed over it in an incandescent state, may be owing to some of these impregnations; for a quantity of noxious effluvia, inappreciably small, is capable of affecting not only the olfactory nerves, but the pulmonary organs. I endeavoured to test the air as it issued from the valve in the Examiner's Room, by presenting to it pieces of white paper moistened with a solution of nitrate of silver, and perceived a slight darkening to take place, as if by sulphurous fumes. White paper, moistened with sulphuretted hydrogen water, was not in the least discoloured. The faint impression on the first test paper may be, probably, ascribed to sulphurous fumes, proceeding from the ignition of the myriads of animal and vegetable matters which constantly float in the atmosphere, as may be seen in the sunbeam admitted into a dark chamber: to this cause, likewise, the offensive smell of air, transmitted over red-hot iron, may in some measure be attributed, as well as to the hydrogen resulting from the decomposition of aqueous vapour, always present in our atmosphere in abundance; especially close to the banks of the Thames, below London Bridge.

"When a column of air sweeps furiously across the burning deserts of Africa and Arabia, constituting the phenomenon called simoom by the natives, the air becomes not only very hot and dry, but highly electrical, as is evinced by lightning and thunder. Dry sands, devoid of vegetation, cannot be conceived to communicate any noxious gas or vapour to the atmosphere, like the malaria of marshes, called miasmata: it is, hence, highly probable that the blast of the simoom owes its deadly malignity, in reference to

animal as well as vegetable life, simply to extreme heat, dryness, and electrical disturbance. Similar conditions, though on a smaller scale, exist in what is called the bell, or cockle, apparatus for heating the Long Room and the Examiner's apartment in the Custom-house. It consists of a series of inverted, hollow, flattened pyramids of cast-iron, with an oblong base, rather small in their dimensions, to do their work sufficiently in cold weather, when moderately heated. The inside of the pyramids is exposed to the flames of coke furnaces, which heat them frequently to incandescence, while currents of cold air are directed to their exterior surfaces by numerous sheet-iron channels. The incandescence of these pyramids, or bells, as they are vulgarly called, was proved by pieces of paper taking fire when I laid them on the summits. Again, since air becomes electrical when it is rapidly blown upon the surfaces of certain bodies, it occurred to me that the air which escapes into the Examiner's Room might be in this predicament. It certainly excites the sensation of a cobweb playing round the head, which is well known to all who are familiar with electrical machines. To determine this point, I presented a condensing gold-leaf electrometer to the said current of hot air, and obtained faint divergence with negative electricity. The electricity must be impaired in its tension, however, in consequence of the air escaping through an iron grating, and striking against the flat iron valves, both of which tend to restore the electric equilibrium. The air blast, moreover, by being diffused round the glass of the condenser apparatus, would somewhat mask the appearances. Were it worth while, an apparatus might be readily constructed for determining this point, without any such sources of fallacy. The influence of an atmosphere charged with electricity in exciting headach and confusion of thought in many persons, is universally known.

"The fetid burned odour of the stove air, and its excessive avidity for moisture, are of themselves, however, sufficient causes of the general indisposition produced among the gentlemen who are permanently exposed to it in the discharge of their public duties.

"From there being nearly a vacuum, as to aqueous vapour, in the said air, while there is nearly a plenum in the external atmosphere round about the Custom-house, the vicissitudes of feeling in those who have occasion to go out and in frequently, must be highly detrimental to health. The permanent action of an artificial desiccated air on the animal economy may be stated as follows:—

"The living body is continually emitting a transpirable matter, the quantity of which, in a grown-up man, will depend partly on the activity of the cutaneous exhalents, and partly on the relative dryness or moisture of the circumambient medium. Its average amount, in common circumstances, has been estimated at 20 ounces in 24 hours.

"When plunged in a very dry air, the insensible perspiration will be increased; and, as it is a true evaporation or gasefaction, it will generate cold proportionably to its amount. Those parts of the body which are most insulated in the air, and furthest from the heat, such as the extremities, will feel this refrigerating influence most powerfully. Hence the coldness of the hands and feet, so generally felt by the inmates of the apartment, though its temperature be at or above 60°. The brain, being screened by the skull from this evaporating influence, will remain relatively hot, and will get surcharged, besides, with the fluids which are repelled from the extremities by the condensation, or contraction, of the blood-vessels, caused by cold. Hence the affections of the head, such as tension, and its dangerous consequences. If sensible perspiration happen, from debility, to break forth from a system previously relaxed, and plunged into dry air, so attractive of vapour, it will be of the kind called a cold clammy sweat on the sides and back, as experienced by many inmates of the Long Room.

"Such, in my humble apprehension, is a rationale of the phenomena observed at the Custom-house. Similar effects have resulted from hot-air stoves of a similar kind in many other situations.

"After the most mature physical and medical investigation, I am of opinion that the circumstances above specified cannot act permanently upon human beings, without impairing their constitutions, and reducing the value of their lives. The Directors of the Customs Fund are therefore justified in their apprehensions, 'that the mode of heating the Long Room is injurious to the health of persons employed therein, and that it must unduly shorten the duration of life.'

"It may be admitted, as a general principle, that the comfort of sedentary individuals, occupying large apartments during the winter months, cannot be adequately secured by the mere influx of hot air from separate stove-rooms: it requires the genial influence of radiating surfaces in the apartments themselves, such as of open fires, of pipes, or other vessels filled with hot water or steam. The clothing of our bodies, exposed to such radiation in a pure, fresh, somewhat cool and bracing air, absorbs a much more agreeable warmth than it could acquire by being merely immersed in an atmosphere heated even to 62° Fahr., like that of the Long Room. In the former predicament, the lungs are supplied with a relatively dense air, say at 52° Fahr.; while the external surface of the body or the clothing is maintained at, perhaps, 70° or 75°. This dis-

tinctive circumstance has not, I believe, been hitherto duly considered by the stove doctors, each intent on puffing his own pecuniary interest; but it is obviously one of great importance, and which the English people would do well to keep in view; because it is owing to our domestic apartments being heated by open fires, and our factories by steam pipes, that the health of our population, and the expectation of life among all orders in this country, are so much better than in France and Germany, where hot-air stoves, neither agreeable nor inoffensive, and in endless variety of form, are generally employed.

"In conclusion, I take leave to state to you my firm conviction that the only method of warming your Long Room and subsidiary apartments, combining salubrity, safety, and economy, with convenience in erection and durable comfort in use, is by a series of steam pipes laid along the floor, at the line of the desk partitions, in suitable lengths, with small arched junction-pipes rising over the several doorways, to keep the passages clear, and at the same time to allow a free expansion and contraction in the pipes, thereby providing for the permanent soundness of the joints."

It would not be difficult to construct a stove or stove-grate which should combine economy and comfort of warming an apartment, with briskness of combustion and durability of the fire, without any noxious deflux of carbonic acid. See *CHIMNEY*.

STRASS; see PASTES.

STRAW-HAT MANUFACTURE. The mode of preparing the Tuscany or Italian straw, is by pulling the bearded wheat while the ear is in a soft milky state, the corn having been sown very close, and of consequence produced in a thin, short, and dwindled condition. The straw, with its ears and roots, is spread out thinly upon the ground in fine hot weather, for 3 or 4 days or more, in order to dry the sap; it is then tied up in bundles and stacked, for the purpose of enabling the heat of the mow to drive off any remaining moisture. It is important to keep the ends of the straw air-tight, in order to retain the pith, and prevent its gummy particles from passing off by evaporation.

After the straw has been about a month in the mow, it is removed to a meadow and spread out, that the dew may set upon it, together with the sun and air, and promote the bleaching, it being necessary frequently to turn the straw while this process is going on. The first process of bleaching being complete, the lower joint and root is pulled from the straw, leaving the upper part fit for use, which is then sorted according to qualities; and after being submitted to the action of steam, for the purpose of extracting its colour, and then to a fumigation of sulphur, to complete the bleaching, the straws are in a condition to be platted or woven into hats and bonnets, and are in that state imported into England in bundles, the dried ears of the wheat being still on the straw.

Straw may be easily bleached by a solution of chloride of lime, and also by sulphuring. For the latter purpose, a cask open at both ends, with its seams papered, is to be set upright a few inches from the ground, having a hoop nailed to its inside, about six inches beneath the top, to support another hoop with a net stretched across it, upon which the straw is to be laid in successive handfuls loosely crossing each other. The cask having been covered with a tight overlapping lid, stuffed with lists of cloth, a brazier of burning charcoal is to be inserted within the bottom, and an iron dish containing pieces of brimstone is to be put upon the brazier. The brimstone soon takes fire, and fills the cask with sulphurous acid gas, whereby the straw gets bleached in the course of three or four hours. Care should be taken to prevent such a violent combustion of the sulphur as might cause black burned spots, for these cannot be afterwards removed. The straw, after being aired and softened by spreading it upon the grass for a night, is ready to be split, preparatory to dyeing. Blue is given by a boiling-hot solution of indigo in sulphuric acid, called *Saxon blue*, diluted to the desired shade; yellow, by decoction of turmeric; red, by boiling hanks of coarse scarlet wool in a bath of weak alum water, containing the straw; or directly, by cochineal, salt of tin, and tartar. Brazil wood and archil are also employed for dyeing straw. For the other colours, see their respective titles in this Dictionary.

STREAM-WORKS. The name given by the Cornish miners to alluvial deposits of tin ore, usually worked in the open air.

STRETCHING MACHINE. Cotton goods and other textile fabrics, either white or printed, are prepared for the market by being stretched in a proper machine, which lays all their warp and woof yarns in truly parallel positions. A very ingenious and effective mechanism of this kind was made the subject of a patent by Mr. Samuel Morand, of Manchester, in April, 1834, which serves to extend the width of calico pieces, or of other cloths woven of cotton, wool, silk, or flax, after they have become shrunk in the processes of bleaching, dyeing, &c. I regret that the limits of this volume will not admit of its description. The specification of the patent is published in *Newton's Journal*, for December, 1835.

STRINGS. The name given by the Cornish miners to the small filamentous ramifications of a metallic vein.

STRONTIA, one of the alkaline earths, of which *strontium* is the metallic basis, occurs in a crystalline state, as a carbonate, in the lead mines of Strontian in Argyleshire, whence its name. The sulphate is found crystallised near Bristol, and in several other parts of the world; but strontic minerals are rather rare. The pure earth is prepared exactly like baryta, from either the carbonate or the sulphate. It is a grayish-white powder, infusible in the furnace, of a specific gravity approaching that of baryta, having an acrid, burning taste, but not so corrosive as baryta, though sharper than lime. It becomes hot when moistened, and slakes into a pulverulent hydrate, dissolves in 150 parts of water at 60°, and in much less at the boiling point, forming an alkaline solution, called *strontia* water, which deposits crystals in four-sided tables as it cools. These contain 68 per cent. of water, are soluble in 52 parts of water at 60°, and in about 2 parts of boiling water; when heated they part with 53 parts of water, but retain the other 15 parts, even at a red heat. The dry earth consists of 84.55 of base, and 15.45 of oxygen. It is readily distinguished from baryta, by its inferior solubility, and by its soluble salts giving a red tinge to flame, while those of baryta give a yellow tinge. Fluosilicic acid and iodate of soda precipitate the salts of the latter earth, but not those of the former. The compounds of strontia are not poisonous, like those of baryta. The only preparation of strontia used in the arts is the **NITRATE**, which see.

STRYCHNIA, is an alkaline base, extracted from the *Strychnos nux vomica*, *Strychnos ignatia*, and the *Upas tiente*; which has been employed in medicine by some of the poison doctors, but is of no use in any of the arts. When introduced into the stomach, strychnia acts with fearful energy, causing lock-jaw immediately, and the death of the animal in a very short time. Half a grain, blown into the throat of a rabbit, proves fatal in five minutes.

Having placed a drop of strong sulphuric acid on a piece of glass, add to it a small quantity of the suspected substance, and stir the whole together, so as to favour solution; then sprinkle over the mixture a little powdered bichromate of potash, and gently move a glass rod through the fluid. If strychnia be present, a violet colour of considerable beauty will be almost immediately produced, which, after a few minutes, will fade into a reddish yellow, but may be renewed by the addition of more bichromate, so long as any strychnia remains undestroyed in the mixture. In this way $\frac{1}{1000}$ of a grain of that alkaloid may be made to yield a very decisive indication. The points to be noticed are that sulphuric acid alone produces no apparent effect, and that the action begins at once round each particle of the bichromate, so that if the glass be held in a vertical position, streams of a violet coloured fluid may be seen to flow from each particle; and if at this time, the whole be slowly stirred, the entire bulk of the fluid will speedily assume the same characteristic tint.

In conjunction with my friend, Mr. Morson, of Southampton Row, I have thus examined the following alkaloids: morphia, brucia, aconita, atropia, codia, narcotina, pierotoxia, cinchonia, quina, solania, veratria, and phloridza, but without noticing anything at all calculated to throw a doubt upon the value of the indication thus obtained, as a means of demonstrating the presence of strychnia. In these experiments the usual sources of error were sought to be avoided by the employment of pure materials: the alkaloids having been manufactured with great care. Compounds containing nitric or muriatic acid are, for obvious reasons, unfit for such investigations—the pure alkaloids and their sulphates being alone unobjectionable.—*Mr. Lewis Thompson.*

STUCCO. See **GYPSEUM**.

SUBERIC ACID, is prepared by digesting grated cork with nitric acid. It forms crystals, which sublime in white vapours when heated.

SUBLIMATE, is any solid matter resulting from condensed vapours, and,

SUBLIMATION, is the process by which the volatile particles are raised by heat, and condensed into a crystalline mass. See **CALOMEL** and **SAL-AMMONIAC**, for examples.

SUBSALT, is a salt in which the base is not saturated with acid; as subsacetate of lead.

SUCCINIC ACID, *Acid of amber*, (*Acide succinique*, Fr.; *Bernsteinsäure*, Germ.) is obtained by distilling coarsely pounded amber in a retort by itself, with a heat gradually raised; or mixed with one-twelfth of its weight of sulphuric acid, diluted with half its weight of water. The acid which sublimes is to be dissolved in hot water, to be saturated with potassa or soda, boiled with bone black, to remove the foul empyreumatic oily matter, filtered, and precipitated by nitrate of lead, to convert it into an insoluble succinate; which being washed, is to be decomposed by the equivalent quantity of sulphuric acid. Pure succinic acid forms transparent prisms. The succinate of ammonia is an excellent reagent for detecting and separating iron.

SUGAR (*Sucre*, Fr.; *Zucker*, Germ.); is the sweet constituent of vegetable and animal products. It may be distinguished into two principal species. The first, which occurs in the sugar-cane, the beet-root, and the maple, crystallizes in oblique four-sided prisms, terminated by two-sided summits; it has a sweetening power which may be

represented by 100; and in circumpolarization it bends the luminous rays to the right. The second occurs readily formed in ripe grapes and other fruits; it is also produced by treating starch with diastase or sulphuric acid. This species forms cauliflower concretions, but not true crystals; it has a sweetening power, which may be represented by 60, and in circumpolarization it bends the rays to the left. Besides these two principal kinds of sugar, some others are distinguished by chemists; as the sugar of milk, of manna, of certain mushrooms, of liquorice-root, and that obtained from sawdust and glue by the action of sulphuric acid; but they have no importance in a manufacturing point of view.

Sugar, extracted either from the cane, the beet, or the maple, is identical in its properties and composition, when refined to the same pitch of purity; only that of the beet seems to surpass the other two in cohesive force, since larger and firmer crystals of it are obtained from a clarified solution of equal density. It contains 5.3 per cent. of combined water, which can be separated only by uniting it with oxide of lead, into what has been called a saccharate; made by mixing syrup with finely ground litharge, and evaporating the mixture to dryness upon a steam-bath. When sugar is exposed to a heat of 400° F., it melts into a brown pasty mass, but still retains its water of composition. Sugar thus fused is no longer capable of crystallization, and is called caramel by the French. It is used for colouring liqueurs. Indeed sugar is so susceptible of change by heat, that if a colourless solution of it be exposed for some time to the temperature of boiling water, it becomes brown and partially uncrystallizable. Acids exercise such an injurious influence upon sugar, that after remaining in contact with it for a little while, though they be rendered thoroughly neutral, a great part of the sugar will refuse to crystallize. Thus, if 3 parts of oxalic or tartaric acid be added to sugar in solution, no crystals of sugar can be obtained by evaporation, even though the acids be neutralized by chalk or carbonate of lime. By boiling cane sugar with dilute sulphuric acid, it is changed into starch sugar. Manufacturers of sugar should be, therefore, particularly watchful against every acidulous taint or impregnation. Nitric acid converts sugar into oxalic and malic acids. Alkaline matter is likewise most detrimental to the grain of sugar; as is always evinced by the large quantity of molasses formed, when an excess of temper lime has been used in clarifying the juice of the cane or the beet. When one piece of lump sugar is rubbed against another in the dark, a phosphorescent light is emitted.

Sugar is soluble in all proportions in water; but it takes four parts of spirits of wine, of spec. grav. 0.830, and 80 of absolute alcohol, to dissolve it, both being at a boiling temperature. As the alcohol cools, it deposits the sugar in small crystals. Carmelized and uncrystallizable sugar dissolves readily in alcohol. Pure sugar is unchangeable in the air, even when dissolved in a good deal of water, if the solution be kept covered and in the dark; but with a very small addition of gluten, the solution soon begins to ferment, whereby the sugar is decomposed into alcohol and carbonic acid, and ultimately into acetic acid.

Sugar forms chemical compounds with the salifiable bases. It dissolves readily in caustic potash lye, whereby it loses its sweet taste, and affords on evaporation a mass which is insoluble in alcohol. When the lye is neutralized by sulphuric acid, the sugar recovers its sweet taste, and may be separated from the sulphate of potash by alcohol, but it will no longer crystallize.

That syrup possesses the property of dissolving the alkaline earths, limes, magnesia, strontites, barytes, was demonstrated long ago by Mr. Ramsay, of Glasgow, by experiments published in *Nicholson's Journal*, vol. xviii. page 9, for September, 1807. He found that syrup is capable of dissolving half as much lime as it contains of sugar; and as much strontites as sugar. Magnesia dissolved in much smaller quantity and barytes seemed to decompose the sugar entirely. These results have been since confirmed by Professor Daniel. Mr. Ramsay characterized sugar treated with lime as weak, from its sweetening power being impaired; from its solution he obtained, after some time, a deposit of calcareous carbonate. M. Pelouze has lately shown that the carbonic acid in this case is derived from the atmosphere, and is not formed at the expense of the elements of the sugar, as Mr. Daniel had asserted.

Sugar forms with oxide of lead two combinations; the one soluble, the other insoluble. Oxide of lead digested in syrup dissolves to a certain amount, forms a yellowish liquor, which possesses an alkaline reaction, and leaves after evaporation an uncrystallizable, viscid, deliquescent mass. If syrup be boiled with oxide of lead in excess, if the solution be filtered boiling hot, and if the phial be corked in which it is received, white bulky flocks will fall to its bottom in the course of 24 hours. This compound is best dried *in vacuo*. It is in both cases light, tasteless, and insoluble in cold and boiling water; it takes fire like German tinder (AMADOU), when touched at one point with an ignited body, and burns away, leaving small globules of lead. It dissolves in acids, and also in neutral acetate of lead, which forms with the oxide a subsalt, and sets the sugar free.

Carbonic acid gas passed through water in which the above saccharate is diffused, decomposes it, with precipitation of carbonate of lead. It consists of 58.26 parts of oxide of lead, and 41.74 sugar, in 100 parts. From the powerful action exercised upon sugar by acids and oxide of lead, we may see the fallacy and danger of using these chemical reagents in sugar-refining. Sugar possesses the remarkable property of dissolving the oxide, as well as the subacetate of copper (*verdigris*), and of counteracting their poisonous operation. Orfila found that a dose of *verdigris*, which would kill a dog in an hour or two, might be swallowed with impunity, provided it was mixed with a considerable quantity of sugar. When a solution of sugar is boiled with the acetate of copper, it causes an abundant precipitate of protoxide of copper; when boiled with the nitrates of mercury and silver, or the chloride of gold, it reduces the respective bases to the metallic state.

The following TABLE shows the quantities of Sugar contained in Syrups of the annexed specific gravities.* It was the result of experiments carefully made.

| Experimental Spec. Grav. of Solution at 60° Fahr. | Sugar in 100 by Weight. | Exper. Spec. Grav. of Solution at 60° Fahr. | Sugar in 100 by Weight. |
|---|-------------------------|---|-------------------------|
| 1.3260 | 66.666 | 1.1045 | 25.000 |
| 1.2810 | 50.000 | 1.0905 | 21.740 |
| 1.1777 | 40.000 | 1.0820 | 20.000 |
| 1.4400 | 33.333 | 1.0685 | 16.666 |
| 1.1340 | 31.250 | 1.0500 | 12.500 |
| 1.1250 | 29.412 | 1.0395 | 10.000 |
| 1.1110 | 26.316 | | |

If the decimal part of the number denoting the specific gravity of syrup, be multiplied by 26, the product will denote very nearly the quantity of sugar per gallon in pounds weight, at the given specific gravity.†

Sugar has been analysed by several chemists; the following TABLE exhibits some of their results:—

| | Gay Lussac and Thenard. | Berzelius. | Prout. | Ure. | |
|--------------|-------------------------|------------|--------|-------|--------|
| Oxygen - - | 56.63 | 49.856 | 53.35 | 50.33 | in 100 |
| Carbon - - | 42.47 | 43.265 | 39.99 | 43.38 | — |
| Hydrogen - - | 6.90 | 6.875 | 6.66 | 6.29 | — |

Of the sugar cane, and the extraction of sugar from it.—Humboldt, after the most elaborate historical and botanical researches in the New World, has arrived at the conclusion, that before America was discovered by the Spaniards, the inhabitants of that continent and the adjacent islands were entirely unacquainted with the sugar canes, with any of our corn plants, and with rice. The progressive diffusion of the cane has been thus traced out by the partisans of its oriental origin. From the interior of Asia it was transplanted first into Cyprus, and thence into Sicily, or possibly by the Saracens directly into the latter island, in which a large quantity of sugar was manufactured in the year 1148. Lafitau relates the donation made by William the Second, king of Sicily, to the convent of St. Benoit, of a mill for crushing sugar canes, along with all its privileges, workmen, and dependencies: which remarkable gift bears the date of 1166. According to this author, the sugar cane must have been imported into Europe at the period of the Crusades. The monk Albertus Aquensis, in the description which he has given of the processes employed at Acre and at Tripoli to extract sugar, says, that in the Holy Land, the Christian soldiers being short of provisions, had recourse to sugar canes, which they chewed for subsistence. Towards the year 1420, Dom Henry, regent of Portugal, caused the sugar cane to be imported into Madeira from Sicily. This plant succeeded perfectly in Madeira and the Canaries; and until the discovery of America these islands supplied Europe with the greater portion of the sugar which it consumed.

The cane is said by some to have passed from the Canaries into the Brazils; but by others, from the coast of Angola in Africa, where the Portuguese had a sugar colony. It was transported in 1506, from the Brazils and the Canaries, into Hispaniola or Hayti, where several crushing-mills were constructed in a short time. It would appear,

* The author, in minutes of evidence of Molasses Committee of the House of Commons, 1831, p. 149.

† This rule was annexed to an extensive table, representing the quantities of sugar per gallon corresponding to the specific gravities of the syrup, constructed by the author for the Excise, in subserviency to the Beet-root Bill.

moreover, from the statement of Peter Martyr, in the third book of his first Decade, written during the second expedition of Christopher Columbus, which happened between 1493 and 1495, that even at this date the cultivation of the sugar cane was widely spread in St. Domingo. It may therefore be supposed to have been introduced here by Columbus himself, at his first voyage, along with other productions of Spain and the Canaries, and that its cultivation had come into considerable activity at the period of his second expedition. Towards the middle of the 17th century, the sugar cane was imported into Barbadoes from Brazil, then into the other English West Indian possessions, into the Spanish Islands on the coast of America, into Mexico, Peru, Chile, and, last of all, into the French, Dutch, and Danish colonies.

The sugar cane, *Arundo saccharifera*, is a plant of the graminiferous family, which varies in height from 8 to 10, or even to 20 feet. Its diameter is about an inch and a half; its stem is dense, brittle, and of a green hue, which verges to yellow at the approach of maturity. It is divided by prominent annular joints of a whitish-yellow colour, the plane of which is perpendicular to the axis of the stem. These joints are placed about 3 inches apart; and send forth leaves, which fall off with the ripening of the plant. The leaves are 3 or 4 feet long, flat, straight, pointed, from 1 to 2 inches in breadth, of a sea-green tint, striated in their length, alternate, embracing the stem by their base. They are marked along their edges with almost imperceptible teeth. In the 11th or 12th month of their growth, the canes push forth at their top a sprout 7 or 8 feet in height, nearly half an inch in diameter, smooth, and without joints, to which the name *arrow* is given. This is terminated by an ample panicle, about 2 feet long, divided into several knotty ramifications, composed of very numerous flowers, of a white colour, apetalous, and furnished with 3 stamens, the anthers of which are a little oblong. The roots of the sugar cane are jointed and nearly cylindrical; in diameter they are about one twelfth of an inch; in their utmost length 1 foot, presenting over their surface a few short radicles.

The stem of the cane in its ripe state is heavy, very smooth, brittle, of a yellowish-violet, or whitish colour, according to the variety. It is filled with a fibrous, spongy, dirty-white pith, which contains very abundant sweet juice. This juice is elaborated separately in each internodary portion, the functions of which are in this respect independent of the portions above and below. The cane may be propagated by seeds or buds with equal facility; but it is usually done by cuttings or joints of proper lengths, from 15 to 20 inches, in proportion to the nearness of the joints, which are generally taken from the tops of the canes, just below the leaves.

There are several varieties of the sugar-cane plant. The first, and longest known, is the creole, or common sugar cane, which was originally introduced at Madeira. It grows freely in every region within the tropics, on a moist soil, even at an elevation of 3000 feet above the level of the sea. In Mexico, among the mountains of Caudina-Masca, it is cultivated to a height of more than 5000 feet. The quantity and quality of sugar which it yields, is proportional to the heat of the place where it grows, provided it be not too moist and marshy.

The second variety of this plant is the Otahaitan cane. It was introduced into the West Indies about the end of the 18th century. This variety, stronger, taller, with longer spaces between the joints, quicker in its growth, and much more productive in sugar, succeeds perfectly well in lands which seem too much impoverished to grow the ordinary cane. It sends forth shoots at temperatures which chill the growth and development of the creole plant. Its maturation does not take more than a year, and is accomplished sometimes in nine months. From the strength of its stem, and the woodiness of its fibres, it better resists the storms. It displays a better inflorescence, weighs a third more, affords a sixth more juice, and a fourth more sugar, than the common variety. Its main advantage, however, is to yield four crops in the same time that the creole cane yields only three. Its juice contains less feculency and mucilage, whence its sugar is more easily crystallized, and of a fairer colour.

Besides these two varieties, another kind is described by Humboldt and Bonpland, under the name of the *violet* sugar-cane, for its haulm and leaves are of this colour. It was transported from Batavia in 1782. It flowers a month sooner than the rest, that is, in August, but it yields less solid sugar, and more liquid, both of which have a violet tint.

In saying that the cane may be propagated by seeds as well as buds, we must remark, that in all the colonies of the New World, the plant flowers, indeed, but it then sends forth a shoot (*arrow*), that is, its stem elongates, and the seed-vessel prove abortive. For this reason, the bud-joints must there be used for its propagation. It grows to seed however, in India. This circumstance occurs with some other plants, which, when propagated by their roots, cease to yield fertile seeds; such as the banana, the bread-fruit, the lily, and the tulip.

In the proper season for planting, the ground is marked out by a line into rows 3 or 4 feet asunder, in which rows the canes are planted about 2 feet apart. The

series of rows is divided into pieces of land 60 or 70 feet broad, leaving spaces of about 20 feet, for the convenience of passage, and for the admission of sun and air between the stems. Canes are usually planted in trenches, about 6 or 8 inches deep, made with the hand-hoe, the raised soil being heaped to one side, for covering-in the young cane; into the holes a negro drops the number of cuttings intended to be inserted, the digging being performed by other negroes. The earth is then drawn about the hillocks with the hoe. This labour has been, however, in many places better and more cheaply performed by the plough; a deep furrow being made, into which the cuttings are regularly planted, and the mould then properly turned in. If the ground is to be afterwards kept clear by the horse-hoe, the rows of canes should be 5 feet asunder, and the hillocks $2\frac{1}{2}$ feet distant, with only one cane left in one hillock. After some shoots appear, the sooner the horse-hoe is used, the more will the plants thrive, by keeping the weeds under, and stirring up the soil. Plant-canes of the first growth have been known to yield, on the brick-mould of Jamaica, in very fine seasons, $2\frac{1}{2}$ tons of sugar per acre. The proper season for planting the canes, namely, containing the buds, namely, the top part of the cane stripped of its leaves, and the two or three upper joints, is in the interval between August and the beginning of November. Favoured by the autumnal weather, the young plants become luxuriant enough to shade the ground before the dry season sets in; thereby keeping the roots cool and moderately moist. By this arrangement the creole canes are ripe for the mill in the beginning of the second year, so as to enable the manager to finish his crop early in June. There is no greater error in the colonist than planting canes at an improper season of the year, whereby his whole system of operations becomes disturbed and, in a certain degree, abortive.

The withering and fall of a leaf afford a good criterion of the maturity of the cane-joint to which it belonged; so that the eight last leafless joints of two canes, which are cut the same day, have exactly the same age and the same ripeness, though one of the canes be 15 and the other only 10 months old. Those, however, cut towards the end of the dry season, before the rains begin to fall, produce better sugar than those cut in the rainy season, as they are then somewhat diluted with watery juice, and require more evaporation to form sugar. It may be reckoned a fair average product, when one pound of sugar is obtained from one gallon (English) of juice.

Rattoons (a word corrupted from *rejections*) are the sprouts or suckers that spring from the roots or stoles of the canes that have been previously cut for sugar. They are commonly ripe in 12 months; but canes of the first growth are called plant-canes, being the direct produce of the original cuttings or germs placed in the ground, and require a longer period to bring them to maturity. The first yearly return from the roots that are cut over, are called first ratoons; the second year's growth, second ratoons; and so on, according to their age. Instead of stocking up his ratoons, holing, and planting the land anew, the planter suffers the stoles to continue in the ground, and contents himself, as the cane-fields become thin and impoverished, with supplying the vacant places with fresh plants. By these means, and with the aid of manure, the produce of sugar per acre, if not apparently equal to that from plant-canes, gives perhaps in the long run as great returns to the owner, considering the relative proportion of the labour and expense attending the different systems. The common yielding on proper land, such as the red soil of Trelawney, in Jamaica, in 7 hogsheads, of 16 cwt. each, to 10 acres of ratoons cut annually; and such a plantation lasts from 6 to 10 years.

When the planted canes are ripe, they are cut close above the ground by an oblique section, into lengths of 3 or 4 feet, and transported in bundles to the mill-house. If the roots be then cut off a few inches below the surface of the soil, and covered up with fine mould, they will push forth more prolific offsets or ratoons, than when left projecting in the common way.

The recent researches of the eminent French chemist, M. Casaseca, upon cane juice, at Havana in Cuba, have demonstrated clearly the enormous loss which sugar-planters suffer by the imperfection of their manufacturing processes. His results confirm those previously obtained by M. Peligot in Paris, and show that cane juice evaporated in vacuo at the atmospheric temperature yields, in 100 parts, —

| | | | |
|--------------------------------------|---|---|-------|
| Crystalline white sugar | - | - | 20.94 |
| Water | - | - | 78.80 |
| Mineral substances | - | - | 0.14 |
| Organic matter, different from sugar | - | - | 0.12 |

The cane from which the above juice was drawn is called *casaca la tierra* in Cuba. The juice of the Otaheite cane is identical with the preceding. But the proportions of ligneous fibres in the two canes are very different; that of *la tierra* containing, according to M. Casaseca, 16.4 per cent., while that of Otaheite contains only 10. Other canes, however, differ in this respect considerably from these two varieties. The average quantity of grained sugar obtained from cane juice in our colonial plantations is probably not more than one third of the quantity of crystalline sugar in the juice which they boil.

The following analysis of cane juice, performed by a French chemist, was given me by Mr. Forstall of New Orleans. In 10 English gallons, of 231 cubic inches each of juice marking 8½° Baumé, there are 5½ ounces English of salts, which consist of—

| | | | |
|-----------------------|---|---|-------------------------------------|
| Sulphate of potash | - | - | 17·840 grammes = 15·44 grains each. |
| Phosphate of potash | - | - | 16·028 |
| Chlorure of potassium | - | - | 8·355 |
| Acetate of potash | - | - | 63·750 |
| Acetate of lime | - | - | 36·010 |
| Gelatinous silica | - | - | 15·270 |

157·153 = 5·57 ounces avoirdupois.

To the large proportion of deliquescent saline matter, of which one half, he says remains in the sugar, the analyst ascribes very properly the deliquescence and deterioration of the sugar when kept for some time or transported. It was probably the juice of the cane grown in the rich alluvial soil of Louisianas, and therefore more abundant in saline matter than the average soil of our West India Islands. The Demerara cane-juice has perhaps the above saline constitution, as it suffers much loss of weight by drainage in the home voyage.

OF SUGAR MILLS.

The first machines employed to squeeze the canes, were mills similar to those which serve to crush apples in some cider districts, or somewhat like tan-mills. In the centre of a circular area, of about 7 or 8 feet in diameter, a vertical heavy wheel was made to revolve on its edge, by attaching a horse to a cross beam projecting horizontally from it and making it move in a circular path. The cane pieces were strewed on the somewhat concave bed in the path of the wheel, and the juice expressed flowed away through a channel or gutter in the lowest part. This machine was tedious and unproductive. It was replaced by the vertical cylinder-mill of Gonzales de Velosa; which has continued till modern times, with little variation of external form, but is now generally superseded by the sugar-mill with horizontal cylinders.

Specification of, and Observations on, the Construction and Use of the best Horizontal Sugar-mill.

Fig. 1385. Front elevation of the entire mill. *Fig. 1386.* Horizontal plan. *Fig. 1387.* End elevation. *Fig. 1388.* Diagram, showing the dispositions of the feeding and delivering rollers, feeding board, returner, and delivering board.

Fig. 1385. A, A, solid foundation of masonry; a, a, bed plate; c, c, headstocks or standards; D, main shaft (seen only in *fig. 1386.*); z, intermediate shaft; r, r, plummer-blocks of main shaft D (seen only in *fig. 1386.*); x, driving pinion on the fly-wheel shaft of engine; l, first motion mortise wheel, driven by the pinion; x, second motion pinion, on the same shaft; l, second motion mortise-wheel, on the main shaft; m, brays of wood, holding the plummer-blocks for shaft D; n, wrought-iron straps connecting the brays to the standards c, c; o, o, regulating screws for the brays; r, top roller and gudgeons; q and a, the lower or feeding and delivering rollers; s, clutch for the connexion of the side of lower rollers q and a, to the main shaft (seen only in *fig. 1386.*); z, z, the drain gutters of the mill-bed (seen only in *fig. 1386.*)

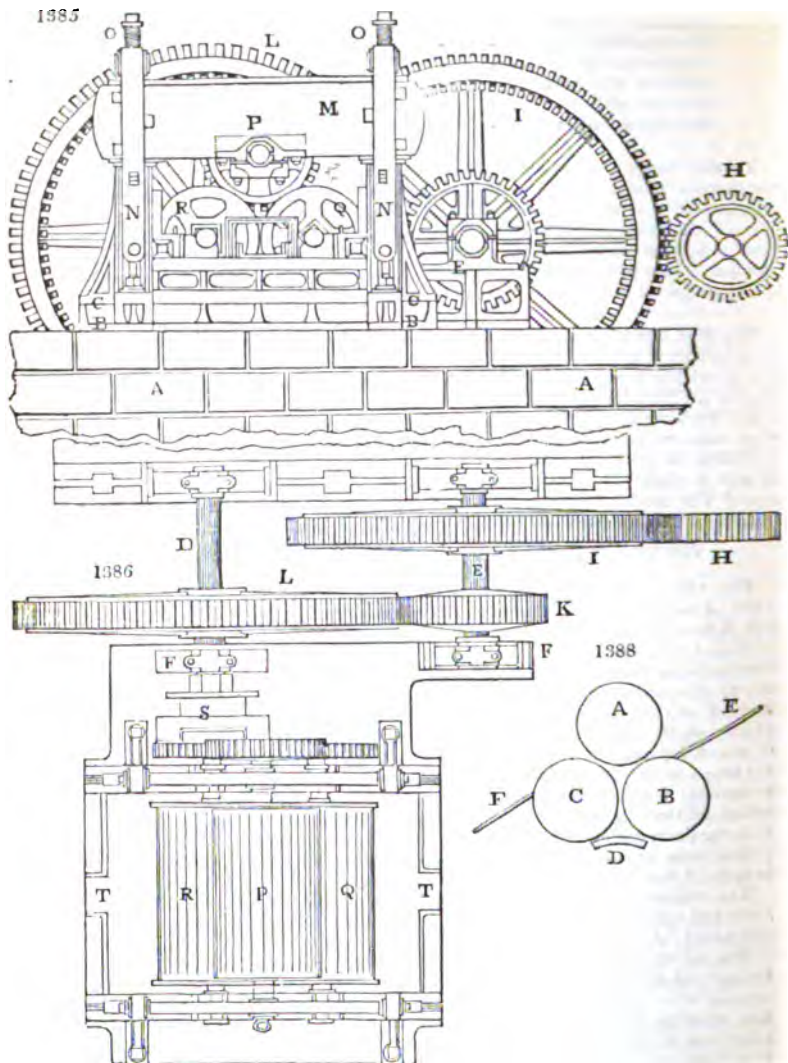
The same letters of reference are placed respectively on the same parts of the mill in each of *figs. 1385, 1386, and 1387.*

The relative disposition of the rollers is shown in the diagram, *fig. 1388.*, in which A is the top roller; a, the feeding roller; c, the delivering roller; D, the returner; z, the feed board; r, the delivering board.

The rollers are made 2½ inches to 3½ inches thick, and ribbed in the centre. The feeding and delivering rollers have small flanges at their ends (as shown in *fig. 1385.*), between which the top roller is placed; these flanges prevent the pressed canes or begass from working into the mill-bed. The feeding and top rollers are generally fluted, and sometimes diagonally, enabling them the better to seize the canes from the feed-board. It is, however, on the whole, considered better to flute the feeding roller only, leaving the top and delivery rollers plane; when the top roller is fluted, it should be very slightly, for, after the work of a few weeks, its surface becomes sufficiently rough to bite the canes effectively. The practical disadvantage of fluting the delivering rollers, is in the groves carrying round a portion of liquor, which is speedily absorbed by the spongy begass, as well as in breaking the begass itself, and thus causing great waste.

The feed board is now generally made of cast iron, and is placed at a considerable inclination, to allow the canes to slip the more easily down to the rollers. The returner is also of cast iron, serrated on the edge, to admit the free flowing of the liquor to the mill-bed. The concave returner, formerly used, was pierced with holes to drain off the liquor, but it had the serious disadvantage of the holes choking up with the splinters of the cane, and has therefore been discarded. The delivering board is of cast iron, fitted close to the roller, to detach any begass that may adhere to it, and otherwise mix with the liquor.

In Demerara, Surinam, Cayenne, and the alluvial district of Trinidad, it is usual to attach to the mill a liquor-pump, with two barrels and three adjustments of stroke. This

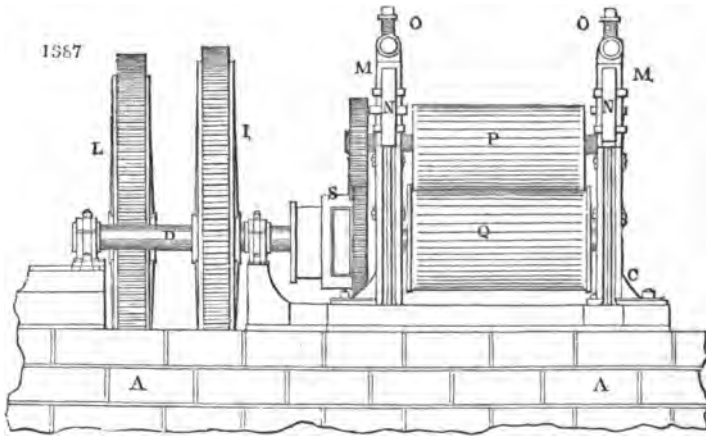


is worked from the gudgeon of the top roller. In action, the liquor from the gutter of the mill-bed runs into the cistern of the pump, and is raised by the pump to the gutter which leads to the clarifier or coppers. Such pumps have brass barrels and copper discharging pipes, are worked with a very slow motion, and require to be carefully adjusted to the quantity of liquor to be raised, which, without such precaution, is either not drawn off sufficiently quick, or is agitated with air in the barrels, and delivered to the gutter in a state of fermentation.

In working this mill, the feeding roller is kept about half an inch distant from the upper roller, but the delivering roller is placed so close to it, as to allow the begass to pass through unbroken.

The practice with this mill is to cut the sugar canes into short lengths of about three feet, and bring them to the mill tied up in small bundles; there the feeder unites them, throws them on the feed board, and spreads them so that they may cross each

other as little as possible. They are taken in by the feed rollers, which split and slightly press them; the liquor flows down, and, the returner guiding the canes between the top and



delivering rollers, they receive the final pressure, and are turned out on the mill-floor, while the liquor runs back and falls into the mill-bed. The bagass, then in the state of *pith*, adhering to the skin of the cane, is tied up in bundles, and after being exposed a short time to the sun, is finally stored in the bagass-house for fuel. By an important improvement in this stage of the process, recently introduced, the bagass is carried to the bagass-house by a carrier chain, worked by the engine.

The relative merits of horizontal and vertical sugar-mills on this construction, may be thus stated:—The horizontal mill is cheaper in construction, and is more easily fixed; the process of feeding is performed at about one-half of the labour, and in a much superior manner; the returner guides the canes to receive the last pressure more perfectly; and the bagass is not so much broken as in the vertical mill; but left tolerably entire, so as to be tied, dried, and stored, with less trouble and waste.

The vertical mill has a considerable advantage, in being more easily washed; and it can be readily and cheaply mounted in wooden framing; but the great labour of feeding the vertical mill, renders it nearly inapplicable to any higher power than that of about ten horses. In situations where the moving power is a windmill, or a cattle gin, the vertical mill may be preferred.

The scale of produce of such mills varies according to the climate and soil. In Demerara, a well constructed engine and mill will produce about 100 gallons of liquor per hour for each horse power.

The dimensions of the most approved horizontal mills are these:—

| Horse-power of Engine. | Length of Rollers. | | Diameter of Rollers. |
|------------------------|--------------------|-----|----------------------|
| | ft. | in. | inches. |
| 8 | 4 | 0 | 25 |
| 10 | 4 | 6 | 27 |
| 12 | 4 | 8 | 28 |

The surface speed of the rollers is 3·4 or 3·6 feet per minute; and to provide for the varying resistance arising from irregular feeding, or the accidental crossing of the canes, by which the engine is often *brought up* so suddenly as to break the fly-wheel shaft, it is necessary to make both the shaft and the fly-wheel of unusual strength and weight.

Sugar is manufactured in the East Indies by two distinct classes of persons; the *ryots*, who raise the sugar cane, extract its juice, and inspissate it to a syrupy consistence; and the *goldars*, who complete the conversion into sugar.

The *ryots* are the farmers, or actual cultivators of the soil; but, properly speaking, they are merely peasants, toiling under oppressive landlords, and miserably poor. After they cut the canes, they extract the juice by one or other of the rude mills or mortars presently to be described, and boil it down to an entire mass, which is generically called *goor*, without making any attempt to clarify it, or separate the granular

sugar from the uncrystallizable molasses. This goor is of various qualities; one of which, in most common use for making sugar, is known amongst the English settlers under the name of *jaggery*. There is a caste in Ceylon, called *jaggeraras*, who make sugar from the produce of the *Caryota urens*, or Kitul tree; and the sugar is styled *jaggery*. Sugar is not usually made in Ceylon from the sugar cane; but either from the juice of the Kitul, from the *Cocos nucifera*, or the *Borassus flabelliformis* (the Palmyra tree).

Several sorts of cane are cultivated in India.

The *Cadjoolee* (fig 1389.) is a purple-coloured cane; yields a sweeter and richer juice than the yellow or light coloured, but in less quantities, and is harder to press. It grows in dry lands. When eaten raw, it is somewhat dry and pithy in the mouth, but is esteemed very good for making sugar. It is not known to the West India planter. The leaves rise from a point 6 feet above the ground. An oblique and transverse section of the cane is represented by the parts near the bottom of the figure.

The *Pooree* is a light-coloured cane, yellow, inclining to white, deeper yellow when ripe and on rich ground. West India planters consider it the same sort as one of theirs. It is softer and more juicy than the preceding, but the juice is less rich, and produces a weaker sugar. It requires seven parts of pooree juice to make as much goor as is produced from six of the cadjoolee. Much of this cane is brought to the Calcutta market, and eaten raw.

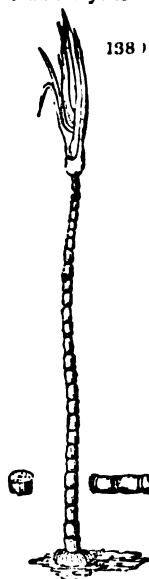
The *Cullorah* thrives in swampy lands, is light-coloured, and grows to a great height. Its juice is more watery, and yields a weaker sugar also than the cadjoolee. However, since much of Bengal consists of low grounds, and since the upland canes are apt to suffer from drought, it deserves encouragement in certain localities.

It is only large farms that cut an acre of cane in a year; one mill, therefore, and one set of the implements used in inspissating the juice, although very rude and simple, serve for several farms, and generally belong to some wealthy man, who lets them out for hire to his poorer neighbours, the whole of whom unite to clear each other's fields by turns; so that though many people and cattle are employed at one of these miserable sets of works, very few indeed are hired, and the greater part of the labour is performed by the common stock of the farms.

The inspissated juice, or extract of cane, called by the natives *goor*, is of two kinds; one of which may be termed cake extract, and the other pot extract; both being often denominated *jaggery*, as above stated, by the English residents.

One-third of an acre of good land in the southern districts, is reckoned by the farmers to produce 18,891 pounds of cane, and 1,159 pounds of pot extract. Its produce in cake extract is about 952 pounds.

I shall now describe the primitive rude mill and boiler used in preparing the extract of sugar cane, and which are usually let to the ryots by the day. The mill in Dinajpur, fig. 1390, is on the principle of a pestle and mortar. The pestle, however, does not beat the canes, but is rubbed against them, as is done in many chemical triturations; and the moving force is two oxen. The mortar is generally a tamarind tree, one end of which is sunk deep in the ground, to give it firmness. The part pro-



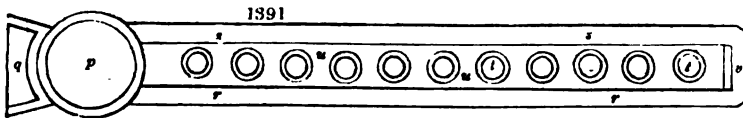
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jecting *a, a, a, a*, may be about two feet high, and a foot and a half in diameter; and in the upper end a hollow is cut, like the small segment of a sphere. In the centre of this, a

channel descends a little way perpendicularly, and then obliquely to one side of the mortar, so that the juice, as squeezed from the cane, runs off, by means of a spout *b*, into a strainer *c*, through which it falls into an earthen pot, that stands in a hole *d*, under the spout. The pestle *e*, is a tree about 18 feet in length, and 1 foot in diameter, rounded at its bottom, which rubs against the mortar, and which is secured in its place by a button or knob, that goes into the channel of the mortar. The moving force is applied to a horizontal beam *f*, about 16 feet in length, which turns round about the mortar, and is fastened to it by a bent bamboo *b*. It is suspended from the upper end of the pestle by a bamboo *g*, which has been cut with part of the root, in which is formed a pivot that hangs on the upper point of the pestle. The cattle are yoked to the horizontal beam, at about ten feet from the mortar, move round it in a circle, and are driven by a man, who sits on the beam, to increase the weight of the triturating power. Scarcely any machine more miserable can be conceived; and it would be totally ineffectual, were not the cane cut into thin slices. This is a troublesome part of the operation. The grinder sits on the ground, having before him a bamboo stake, which is driven into the earth, with a deep notch formed in its upper end. He passes the canes gradually through this notch, and at the same time cuts off the slices with a kind of rude chopper.

The *boiling apparatus* is somewhat better contrived, and is placed under a shed, though the mill is without shelter. The fireplace is a considerable cavity dug in the ground, and covered with an iron boiler *p*, fig. 1391. At one side of this, is an opening *q*, for throwing in fuel; and opposite to this, is another opening, which communicates



with the horizontal flue. This is formed by two parallel mud walls *r*, *r*, *s*, *s*, about 20 feet long, 2 feet high, and 18 inches distant from each other. A row of eleven earthen boilers *t*, is placed on these walls, and the interstices *u*, are filled with clay, which completes the furnace-flue, an opening *v*, being left at the end, for giving vent to the smoke.

The juice, as it comes from the mill, is first put into the earthen boiler that is most distant from the fire, and is gradually removed from one boiler to another, until it reaches the iron one, where the process is completed. The fireplace is manifestly on the same model as the boiler range in the West Indies, and may possibly have suggested it, since the Hindostan furnace is, no doubt, of immemorial usage. The execution of its parts is very rude and imperfect. The inspissated juice that can be prepared in 24 hours by such a mill, with 16 men and 20 oxen, amounts to no more than 476 lbs.; and it is only in the southern parts of the district, where the people work night and day, that the sugar-works are so productive. In the northern districts, the people work only during the day, and inspissate about one-half the quantity of juice. The average daily make of a West India sugar-house, is from 2 to 3 hogshheads, of 16 cwts each.

The Indian manufacturers of sugar purchase the above inspissated juice or goor from the farmers, and generally prefer that of a granular honey consistence, which is offered for sale in pots. As this, however, cannot conveniently be brought from a distance, some of the cake kind is also employed. The boilers are of two sizes: one adapted for making at each operation about ten cwt; the other, about eight and a half. The latter is the segment of a sphere, nine feet diameter at the mouth; the former is larger. The boiler is sunk into a cylindrical cavity in the ground, which serves as a fireplace, so that its edge is just above the floor of the boiling-house. The fuel is thrown in by an aperture close to one side of the boiler, and the smoke escapes by a horizontal chimney that passes out on the opposite side of the hut, and has a small round aperture, about ten feet distant from the wall, in order to lessen the danger from fire. Some manufacturers have only one boiler; others as many as four; but each boiler has a separate hut, in one end of which is some spare fuel; and in the other, some bamboo stages, which support cloth strainers, that are used in the operation. This hut is about twenty-four cubits long, and ten broad; has mud walls, six cubits high; and is raised about one cubit above the ground.

For each boiler, two other houses are required: one in which the cane extract is separated by straining from the molasses, is about twenty cubits long by ten wide; another, about thirty cubits long, by eight wide, is that in which, after the extract has been strained, boiled and clarified, the treacle is separated from the sugar by an operation analogous to claying.

Each sugar manufacturer has a warehouse besides, of a size proportional to the number of his boilers.

About 960 pounds of pot extract being divided into four parts, each is put into a bag of coarse sackcloth, hung over an equal number of wide-mouthed earthen vessels, and is besprinkled with a little water. These drain from the bags about 240 lbs. of a substance analogous to West Indian molasses. The remainder in the bags is a kind of coarse muscovado sugar; but is far from being so well drained and freed from molasses as that of the Antilles. The 720 lbs. of this substance are then put into a boiler with 270 pounds of water, and the mixture is boiled briskly for 144 minutes, when 180 additional pounds of water are added, and the boiling is continued for 48 minutes more. An alkaline solution is prepared from the ashes of the plantain tree, strewed over straw placed in the bottom of an earthen pot perforated with holes. Ninety pounds of water are passed through; and 6 pounds of the clear lixivium are added to the boiling syrup, whereby a thick scum is raised, which is removed. After 24 minutes, four and a half pounds of alkaline solution, and about two-fifths of a pound of raw milk, are added; after which the boiling and skimming are continued 24 minutes. This must be repeated from five to seven times, until no more scum appears. 240 pounds of water being now added, the liquor is to be poured into a number of strainers. These are bags of coarse cotton cloth, in the form of inverted quadrangular pyramids, each of which is suspended from a frame of wood, about 2 feet square. The operation of straining occupies about 96 minutes. The strained liquor is divided into three parts: one of these is put into a boiler, with from half a pound to a pound and a half of alkaline solution, one-twelfth of a pound of milk, and 12 pounds of water. After having boiled for between 48 and 72 minutes, three quarters of a pound of milk are added, and the liquor is poured, in equal portions, into four refining pots. These are wide at the mouth, and pointed at the bottom; but are not conical, for the sides are curved. The bottom is perforated, and the stem of a plantain leaf forms a plug for closing the aperture. The two remaining portions of the strained liquor are managed in exactly the same manner; so that each refining pot has its share of each portion. When they have cooled a little, the refining pot is removed to the curing-house, and placed on the ground for 24 hours; next day they are placed on a frame, which supports them at some distance from the ground. A wide-mouthed vessel is placed under each, to receive the viscid liquor that drains from them. In order to draw off this more completely, moist leaves of the *Valisneria spiralis* are placed over the mouth of the pot, to the thickness of two inches; after 10 or 12 days, these are removed; when a crust of sugar, about half an inch in thickness is found on the surface of the boiled liquor. The crust being broken and removed, fresh leaves are repeatedly added, until the whole sugar has formed; which requires from 75 to 90 days. When cake extract is used, it does not require to be strained before it be put into the boiler.

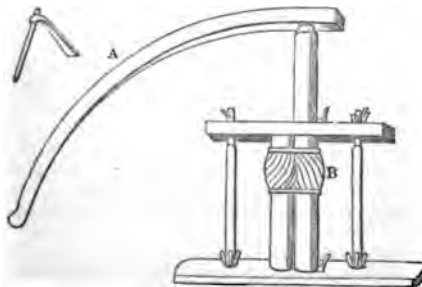
On the above-described operose and preposterous process, it is needless to make any remarks. While it is adhered to with the tenacity of Hindu habit, the West Indies has no reason to fear the competition of the East, in the manufacture of sugar, provided the former avail themselves of the aids which chemical and mechanical science are ready to supply.

In every part of the Behar and Putna districts, several of the confectioners prepare the coarse article called *shukkur*, which is entirely similar in appearance to the inferior Jamaica sugars. They prepare it by putting some of the thin extract of sugar cane into coarse sackcloth bags, and by laying weights on them, they squeeze out the molasses;

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a process perfectly analogous to that contemplated in several English patents.

The sugar-mill at Chica Ballapura is worked by a single pair of buffaloes or oxen, *fig. 1892.*, going round with the lever *A*, which is fixed on the top of the right-hand roller. The two rollers have endless screw heads *B*, which are formed of 4 spiral grooves and 4 spiral ridges, cut in opposite directions, which turn into one another, when the mill is working. These rollers and their heads are of one piece, made of the toughest and hardest wood that can be got, and such



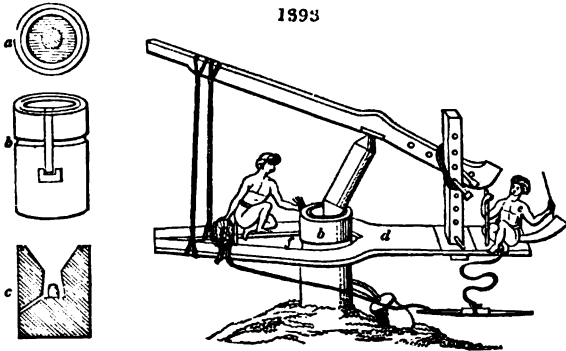
as will not impart any bad taste to the juice. They are supported in a thick strong wooden frame, and their distance from each other is regulated by means of wedges, which pass through mortises in the frame planks, and a groove made in a bit of some

sort of hard wood, and press upon the axis of one of the rollers. The axis of the other presses against the left-hand side of the hole in the frame-boards. The cane juice runs down the rollers, and through a hole in the lower frame-board, into a wooden conductor, which carries it into an earthen pot. Two long-pointed stakes or piles are driven into the earth, to keep the mill steady, which is all the fixing it requires. The under part of the lowermost plank of the frame rests upon the surface of the ground, which is chosen level and very firm, that the piles may hold the faster. A hole is dug in the earth, immediately below the spout of the conductor, to receive the pot.

The mill used in Burdwan and near Calcutta, is simply two small wooden cylinders, grooved, placed horizontally, close to each other, and turned by two men, one at each end. This simple engine is said completely, but slowly, to express the juice. It is very cheap, the prime cost not being two rupees; and being easily moved from field to field, it saves much labour in the carriage of the cane. Notwithstanding this advantage, so rude a machine must leave a large proportion of the richest juice in the cane-trash.

It is curious to find in the ancient arts of Hindostan exact prototypes of the sugar-mills, horizontal and upright, of relatively modern invention in the New World.

The sugar-mill of Chinapatam, *fig. 1393.*, consists of a mortar, lever, pestle, and regulator. The mortar is a tree about 10 feet in length, and 14 inches in diameter: *a* is



a plan of its upper end; *b* is an outside view; and *c* is a vertical section. It is sunk perpendicularly into the earth, leaving one end two feet above the surface. The hollow is conical, truncated downwards, and then becomes cylindrical, with a hemispherical projection in its bottom, to allow the juice to run freely to the small opening that conveys it to a spout, from

which it falls into an earthen pot. Round the upper mouth of the cone is a circular cavity, which collects any of the juice that may run over from the upper ends of the pieces of cane; and thence a canal conveys this juice, down the outside of the mortar, to the spout. The beam *d*, is about sixteen feet in length, and six inches in thickness, being cut out from a large tree that is divided by a fork into two arms. In the fork an excavation is made for the mortar *b*, round which the beam turns horizontally. The surface of this excavation is secured by a semicircle of strong wood. The end towards the fork is quite open, for changing the beam without trouble. On the undivided end of the beam sits the bullock-driver *e*, whose cattle are yoked by a rope which comes from the end of the beam; and they are prevented from dragging out of the circle by another rope, which passes from the yoke to the forked end of the beam. On the arms *f*, a basket is placed, to hold the cuttings of cane; and between this and the mortar sits the man who feeds the mill. Just as the pestle comes round, he places the pieces of cane sloping down into the cavity of the mortar; and after the pestle has passed, he removes those that have been squeezed.

OF THE MANUFACTURE OF SUGAR IN THE WEST INDIES.

Cane-juice varies exceedingly in richness, with the nature of the soil, the culture, the season, and variety of the plant. It is an opaque fluid, of a dull gray, olive, or olive-green colour; in taste, balmy and saccharine; exhaling the balsamic odour of the cane; slightly viscid; and of a specific gravity varying from 1.033 to 1.106, according to circumstances. When fresh, it consists of two parts; the one liquid, the other solid; the latter of which being merely suspended in the former, and, therefore, separable in a great measure by filtration or repose. The solid matter consists of fragments of the cellular parenchyma of the cane, its fibres, and bark, mechanically protruded through the mill; mixed with a very abundant greenish substance, like that called *chlorophyle* by chemists.

When left to itself in the colonial climates, the juice runs rapidly into the acetous fermentation; twenty minutes being, in many cases, sufficient to bring on this destructive change. Hence arises the necessity of subjecting it immediately to clarifying

processes, speedy in their action. When deprived of its green fecula and glutinous extractive, it is still subject to fermentation; but this is now of the vinous kind. The juice flows from the mill through a wooden gutter lined with lead, and being conducted into the sugar-house, is received in a set of large pans or caldrons, called clarifiers. On estates which make on an average, during crop time, from 15 to 20 hogsheads of sugar a week, three clarifiers, of from 300 to 400 gallons' capacity each, are sufficient. With pans of this dimension, the liquor may be drawn off at once by a stopcock or syphon, without disturbing the feculencies after they subside. Each clarifier is hung over a separate fire, the flue being furnished with a damper for checking the combustion, or extinguishing it altogether. The clarifiers are sometimes placed at one end, and sometimes in the middle of the house, particularly if it possesses a double set of evaporating pans.

Whenever the stream from the mill cistern has filled the clarifier with fresh juice, the fire is lighted, and the *temper*, or dose of slaked lime, diffused uniformly through a little juice, is added. If an albuminous emulsion be used to promote the clarifying, very little lime will be required; for recent cane-liquor contains no appreciable portion of acid to be saturated. In fact, the lime and alkalies in general, when used in small quantity, seem to coagulate the glutinous extractive matter of the juice, and thus tend to brighten it up. But if an excess of temper be used, the gluten is taken up again by the strong affinity which is known to exist between sugar and lime. Excess of lime may always be corrected by a little alum-water. Where canes grow on a calcareous marly soil, in a favourable season the saccharine matter gets so thoroughly elaborated, and the glutinous mucilage so completely condensed, that a clear juice and a fine sugar may be obtained without the use of lime.

As the liquor grows hot in the clarifier, a scum is thrown up, consisting of the coagulated feculencies of the cane-juice. The fire is now gradually urged till the temperature approaches the boiling point; to which, however, it must not be suffered to rise. It is known to be sufficiently heated, when the scum rises in blisters, which break into white froth; an appearance observable in about forty minutes after kindling the fire. The damper being shut down, the fire dies out; and after an hour's repose, the clarified liquor is ready to be drawn off into the last and largest in the series of evaporating pans. In the British colonies, these are merely numbered 1, 2, 3, 4, 5, beginning at the smallest, which hangs right over the fire, and is called the *teache*; because in it the trial of the syrup, by *touch*, is made. The flame and smoke proceed in a straight line along a flue to the chimney-stalk at the other end of the furnace. The area of this flue proceeds, with a slight ascent from the fire, to the aperture at the bottom of the chimney; so that between the surface of the grate and the bottom of the *teache*, there is a distance of 28 inches; while between the bottom of the flue and that of the *grand*, No. 5., at the other end of the range, there are barely 18 inches.

In some sugar-houses there is planted, in the angular space between each boiler, a basin, one foot wide and a few inches deep, for the purpose of receiving the *scum* which thence flows off into the *grand copper*, along a gutter scooped out on the margin of the brickwork. The skimmings of the *grand* are thrown into a separate pan, placed at its side. A large cylindrical cooler, about 6 feet wide and 2 feet deep, has been placed in certain sugar-works near the *teache*, for receiving successive charges of its inspissated syrup. Each finished charge is called a skipping, because it is skipped or laded out. The term *striking* is also applied to the act of emptying the *teache*. When upon one skipping of syrup in a state of incipient granulation in the cooler, a second skipping is poured, this second congeries of saccharine particles agglomerates round the first as nuclei of crystallization, and produces a larger grain; a result improved by each successive skipping. This principle has been long known to the chemist, but does not seem to have been always properly considered or appreciated by the sugar-planter.

From the above described cooler, the syrup is transferred into wooden chests or boxes open at top, and of a rectangular shape; also called *coolers*, but which are more properly crystallizers or granulators. These are commonly six in number; each being about one foot deep, seven feet long, and five or six feet wide. When filled, such a mass is collected, as to favour slow cooling, and consequent large-grained crystallization. If these boxes be too shallow, the grain is exceedingly injured, as may be easily shown by pouring some of the same syrup on a small tray; when, on cooling, the sugar will appear like a muddy soft sand.

The criterion by which the negro boilers judge of the due concentration of the syrup in the *teache*, is difficult to describe, and depends almost entirely on the sagacity and experience of the individual. Some of them judge by the appearance of the incipient grain on the back of the cooling ladle; but most decide by "*the touch*," that is, the feel and appearance of a drop of the syrup pressed and then drawn into a thread between the thumb and fore-finger. The thread eventually breaks at a certain limit of extension, shrinking from the thumb to the suspended finger, in lengths somewhat propor-

tional to the inspissation of the syrup. But the appearance of granulation in the thread must also be considered; for a viscid and damaged syrup may give a long enough thread, and yet yield almost no crystalline grains when cooled. Tenacity and granular aspect must therefore be both taken into the account, and will continue to constitute the practical guides to the negro boiler, till a less barbarous mode of concentrating cane-juice be substituted for the present *naked teache*, or *sugar frying-pan*.

That weak sugars are such as contain an inferior proportion of carbon in their composition, was first deduced by me from my experiments on the ultimate analysis of vegetable and animal bodies; an account of which was published in the Philosophical Transactions of the Royal Society for 1822. Since then Dr. Prout has arrived at results confirmatory of my views. See Philosophical Transactions for 1827. Thus, he found pure sugar-candy, and the best refined sugar, to contain 42·85 parts of carbon per cent.; East India sugar-candy, 41·9 parts; East India raw sugar in a thoroughly dry state, but of a low quality, 40·88; manna sugar, well refined, 28·7; sugar from Narbonne honey, 36·36; sugar from starch, 36·2. Hence, by *caramelizing* the syrup in the *teache*, not only is the crystallizable sugar blackened, but its faculty of crystallizing impaired, and the granular portion rendered weaker.

A viscous syrup containing much gluten and sugar, altered by lime, requires a higher temperature to enable it to granulate, than a pure saccharine syrup; and therefore the thermometer, though a useful adjuvant, can by no means be regarded as a sure guide, in determining the proper instant for *striking the teache*.

The colonial *curing-house* is a capacious building, of which the earthen floor is excavated to form the molasses reservoir. This is lined with sheet lead, boards, tarra, or other retentive cement; its bottom slopes a little, and it is partially covered by an open massive frame of joist-work, on which the potting casks are set upright. These are merely empty sugar hogheads, without headings, having 8 or 10 holes bored in their bottoms, through each of which the stalk of a plantain leaf is stuck, so as to protrude downwards 6 or 8 inches below the level of the joists, and to rise above the top of the cask. The act of transferring the crude concrete sugar from the crystallizers into these hogheads, is called potting. The bottom holes, and the spongy stalks stuck in them, allow the molasses to drain slowly downwards into the sunk cistern. In the common mode of procedure, sugar of average quality is kept from 3 to 4 weeks in the curing-house; that which is soft-grained and glutinous, must remain 5 or 6 weeks. The curing-house should be close and warm, to favour the liquefaction and drainage of the viscid caramel.

Out of 120 millions of pounds of raw sugar, which used to be annually shipped by the St. Domingo planters, only 96 millions were landed in France, according to the authority of Dutrone, constituting a loss by drainage in the ships of 20 per cent. The average transport waste at present in the sugars of the British colonies cannot be estimated at less than 12 per cent., or altogether upwards of 27,000 tons! What a tremendous sacrifice of property!

Within these few years a very considerable quantity of sugar has been imported into Great Britain in the state of concentrated cane-juice, containing nearly half its weight of granular sugar, along with more or less molasses, according to the care taken in the boiling operations. I was at first apprehensive that the syrup might undergo some change on the voyage; but among more than a hundred samples which I have analyzed for the custom-house, I have not perceived any traces of fermentation. Since sugar softens in its grain at each successive solution, whatever portion of the crop may be destined for the refiner, should upon no account be granulated in the colonies; but should be transported in the state of a rich cane-syrup to Europe, transferred at once into the blowing-up cistern, subjected there to the reaction of bone black, and passed through bag-filters, or through layers of the coarsely ground black, previously to its final concentration in the vacuum pan. Were this means generally adopted, I am convinced that 30 per cent. would be added to the amount of home-made sugar loaves corresponding to a given quantity of average cane-juice; while 30 per cent., would be taken from the amount of molasses. The saccharine matter now lost by drainage from the hogheads in the ships, amounting to from 10 to 15 per cent., would also be saved. The produce of the cane would, on this plan, require less labour in the colonies, and might be exported 5 or 6 weeks earlier than at present, because the period of drainage in the curing-house would be spared.

It does not appear that our sugar colonists have availed themselves of the proper chemical method of counteracting that incipient fermentation of the cane-juice, which sometimes supervenes, and proves so injurious to their products. It is known that grape-must, feebly impregnated with sulphurous acid, by running it slowly into a cask in which a few sulphur matches have been burned, will keep without alteration for a year; and if *must*, so *muted*, is boiled into a syrup within a week or ten days, it retains no sulphureous odour. A very slight muting would suffice for the most fermentable cane-

juice; and it could be easily given, by burning a sulphur match within the cistern immediately before charging it from the mill. The cane juice should, in this case, be heated in the clarifier, so as to expel the sulphurous acid, before adding the temper lime; for otherwise a little calcareous sulphite might be introduced into the sugar. Thus the aescence so prejudicial to the saccharine granulation would be certainly prevented.

Syrup intended for forming clayed sugar must be somewhat more concentrated in the teache, and run off into a copper cooler, capable of receiving three or four successive skipplings. Here it is stirred to ensure uniformity of product, and is then transferred by ladles into conical moulds, or *formes*, made of coarse pottery, having a small orifice at the apex, which is stopped with a plug of wood wrapped in a leaf of maize. These pots are arranged with the base upwards. As their capacity, when largest, is greatly less than that of the smallest potting-casks, and as the process lasts several weeks, the claying-house requires to have very considerable dimensions. Whenever the syrup is properly granulated, which happens usually in about 18 or 20 hours, the plugs are removed from the apices of the cones, and each is set on an earthen pot to receive the drainings. At the end of 24 hours, the cones are transferred over empty pots, and the molasses contained in the former ones is either sent to the fermenting-house or sold. The claying now begins, which consists in applying to the smoothed surface of the sugar at the base of the cone, a plaster of argillaceous earth, or tolerably tenacious loam in a pasty state. The water diffused among the clay escapes from it by slow infiltration, and descending with like slowness through the body of the sugar, carries along with it the residuary viscid syrup which is more readily soluble than the granulated particles. Whenever the first magma of clay has become dry, it is replaced by a second; and this occasionally in its turn by a third, whereby the sugar cone gets tolerably white and clean. It is then dried in a stove, cut transversely into *frusta*, crushed into a coarse powder on wooden trays, and shipped off for Europe. Clayed sugars are sorted into different shades of colour according to the part of the cone from which they were cut; under the denomination in French commerce of *premier*, *second*, *troisieme*, *petit*, *commun*, and *tete*; the last or the tip being an indifferent article. The clayed sugar of Cuba is called Havannah sugar, from the name of the shipping port.

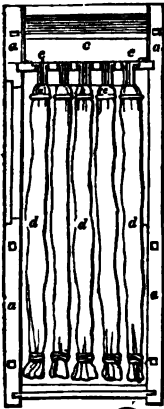
Clayed sugar can be made only from the ripest cane juice, for that which contains much gluten would be apt to get too much burned by the ordinary process of boiling to bear the claying operation. The syrups that run off from the second, third, and fourth application of the clay-paste are concentrated afresh in a small building apart, called the refinery, and yield tolerable sugars. Their drainings go to the molasses cistern. The cones remain for 20 days in the claying-house before the sugar is taken out of them.

Claying is seldom had recourse to in the British plantations, on account of the increase of labour, and diminution of weight in the produce, for which the improvement in quality yields no adequate compensation. Such, however, was the esteem in which the French consumers held clayed sugar, that it was prepared in 400 plantations of St. Domingo alone.

SUGAR REFINING.

Raw, or muscovoda sugar, as imported from the colonies, is contaminated more or less with gluten, lime, but particularly *caramel*, which give its grains a yellow brown tint, an empyreumatic odour, and a soft clammy feel in the hand. If such sugar be dissolved in water, and the syrup be evaporated by a gentle heat, it will afford a sugar of still inferior quality and appearance. The rapid deterioration is in some measure owing to the injurious operation of a prolonged heat upon the crystalline structure, but chiefly to the chemical reaction of the glutinous ferment and lime upon the sugar. The first care of the refiner should therefore be the immediate abstraction of these noxious alteratives, which he effects by the process called *meltings*; that is, mixing up the sugar in a pan with hot water or steam into a pap, and transferring this pap into large sugar-moulds. Whenever these become cool, these points are unplugged, and they are set to drain for a few days in a warm apartment. Sugar thus cleansed is well prepared for the next refining process; which consists in putting it into a large square copper cistern along with some lime-water (a little bullock's blood), and from 5 to 20 per cent. of bone black, and blowing it up with steam; or, in other words, injecting steam through the mixture from numerous orifices in copper pipes laid along the bottom and sides of the vessel. Under the influence of the heat and agitation thus occasioned, the saccharine matter is perfectly dissolved and incorporated with the albumen of the blood and the bone black. Instead of the blood, many refiners employ a mixture of gelatinous alumina and gypsum, called *finings*, prepared by adding a solution of alum to a body of lime-water, collecting, washing, and draining the precipitate upon a filter.

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Other refiners use both the blood and finings with advantage. Bone black is now very frequently employed by the sugar-refiner, not in a fine meal, but in a granular state, like corned gunpowder, for the purpose of decolouring his syrups; in which case, he places it in a box, in a stratum 8 or 10 inches thick, and makes the syrup percolate downwards through it, into a cistern placed beneath. By this means it is deprived of colour, and forms the *clairés* of the French refiner. When the blowing-up cistern is charged with sugar, finely ground bone black, and blood, the mixture must be passed through a proper system of filters. That now most in use is the creased bag filter, represented in the annexed figures.

The apparatus consists of an upright square wooden case *a, a*, about 6 or 8 feet high, furnished with a door of admission to arrange the interior objects; beneath is a cistern with an educting-pipe for receiving and carrying off the filtered liquor; and above the case is another cistern *e*, which, like the rest, is lined with tinned sheet copper. Into the upper cistern, the syrup mixed with animal charcoal is introduced, and passes thence into the mouths *e, e*, of the several filters, *d, d*. These consist, each of a bag of thick tweeled cotton cloth, about 12 or 15 inches in diameter, and 6 or 8 feet long, which is inserted into a narrow bottomless bag of canvas, about 5 inches in diameter, for the purpose of folding the filter-bag up into a small space, and thus enabling a great extent of filtering surfaces to be compressed into one box. The orifice of each compound bag is tied round a conical brass mouth-piece or nozzle *c*, which screws tight into a corresponding opening in the copper bottom of the upper cistern. From 40 to 60 bags are mounted in each filter case. The liquor which first passes is generally tinged

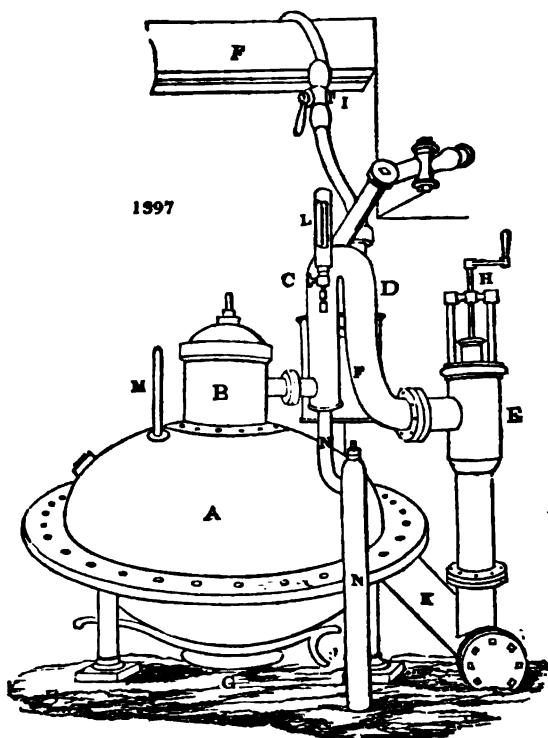
a little with the bone black, and must be pumped back into the upper cistern, for refiltration. In cold weather the interior of the case may be kept warm by a proper distribution of steam-pipes. Fig. 1395. shows one mode of forming the funnel-shaped nozzles of the bags, in which they are fixed by a bayonet catch. Fig. 1396. shows the same made fast by means of a screwed cap, which is more secure.

The next process in sugar-refining is the evaporation of the clarified syrup to the granulating or crystallising pitch. The more rapidly this is effected, and with the less scorching injury from fire, the better and greater is the product in sugar-loaves. No apparatus answers the refiner's double purpose of safety and expedition so well as the vacuum-pan of Howard.

Fig. 1397. shows the structure of a single vacuum-pan. The horizontal diameter of the copper spheroid *A*, is not less than 5 feet; the depth of the under hemisphere is at least 18 inches from the level of the plane; and the height of the dome-cover is 2 feet. The two hemispheres (of which the inferior one is double, or has a steam-jacket,) are put together by bolts and screws, with packing between the flanges to preserve the joints tight against atmospheric pressure. The jacket of the lower hemisphere forms the case of the steam, which communicates heat to the syrup enclosed in the inner hemisphere. In general, the pans contain, when filled to the flange, 100 gallons of syrup, and yield about 11 cwt. of granulated sugar at every charge.

A, represents the vacuum spheroid; *x*, the neck with the lid. From the side of *x*, a pipe passes into the lower extremity of the bent pipe *c, d*, which terminates in the vertical pipe *z*, connected with the vacuum main-pipe *z*, proceeding horizontally from the air-pump (not shown in the figure). At the top of *x*, a valve, movable by a screw *z*, is placed for establishing or cutting off the connexion with the air-pump at pleasure. Behind *x*, is the measure cistern, from which the successive charges are admitted into the pan. This measure is filled with the clear syrup, by opening the stopcock *l*, on the pipe under the ceiling, which communicates with the filter-cistern placed above. *o* is the valve or plug-hole, at the bottom of the pan, for discharging the granulating syrup. This plug is opened by means of a powerful lever attached to it; the connexion with the air-pump being previously intercepted. *h*, is the barometer, or manometer, for showing the state of the vacuum corresponding to the temperature. *m, n*, is a cistern-pipe for receiving any little syrup which may accidentally boil over the neck *x*. Its contents are let off by a stopcock at its bottom from time to time. *m* shows the place of the *proof-stick*, an ingenious brass rod for taking out a sample of syrup without admitting air. See *infra*.

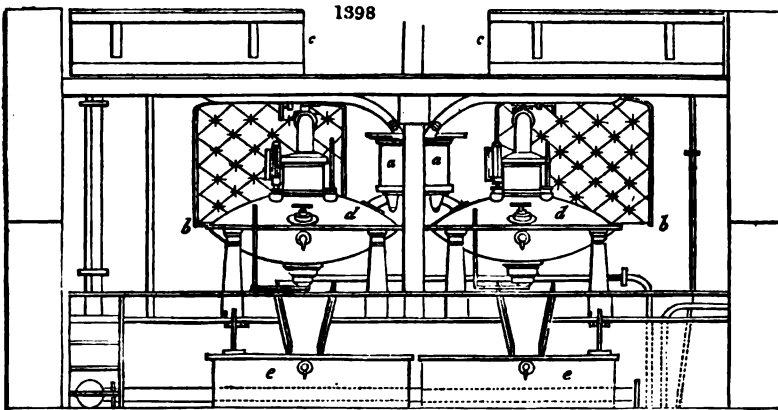
The charging-cistern contains about 20 gallons. This quantity of syrup being first admitted, and brought to a certain pitch of concentration, a second measure is introduced, the inspissation of which is supposed by some refiners to cause an agglomeration.



of saccharine matter round the first crystalline particles. The repetition of this process for two or three times is imagined to produce the large brilliant grain of vacuum-pan sugar. This hypothesis is more specious than sound, because the granulating syrup discharged from the pan is subjected to a heat of 180° or 190° in the subsequent steam-cased receiver, whereby the granulations are again reduced to a very small size. Into this receiver, two or three skippings or discharges of the pan are admitted in succession, and the whole are diligently mixed and agitated by a stirring oar. It is by this process that the granulating tendency is promoted and determined. From this receiver (absurdly enough called a cooler) the moulds are filled in the usual way, by means of copper basins or large ladles.

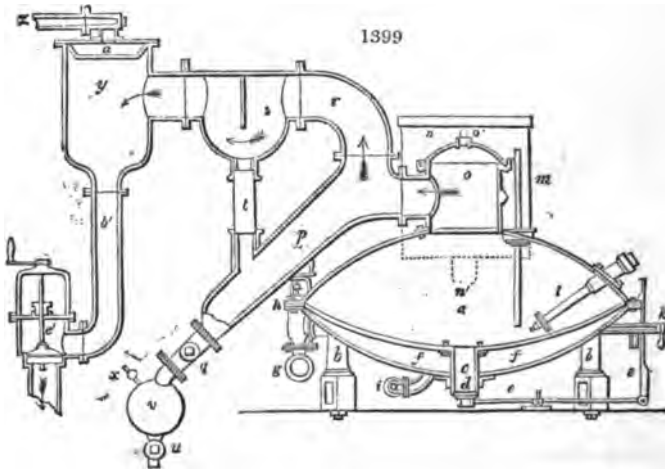
The case of the under hemisphere of the vacuum-pan is filled with steam, generated under a pressure of 4 or 5 pounds on the square inch; the heat of which causes the interior syrup to boil rapidly while the air-pump is kept in action. A small escape-pipe for waste steam must be placed at the opposite side of the case or jacket, to ensure its equal distribution; as also a stopcock below, to let off the water of condensation. The pans are mounted on iron feet, or short pillars, which insulate them from the floor, and allow their whole surface to be inspected, and any flaw to be repaired. The air-pump usually stands in a cold-water cistern, to favour the condensation of the aqueous vapour, which it draws out of the pans; and it is kept in constant action by the steam-engine, being attached to the working-beam of its piston.

Fig. 1396. exhibits the general arrangement of the vacuum-pans, and their subsidiary apparatus. Here are shown, on the ground floor, the heaters *e, e* (miscalled coolers), into which the concentrated syrup is let down. These heaters are made of copper, in one piece, surrounded with a cast-iron jacket, bolted at the flange or brim to it. Each pan contains, when full, about 350 gallons, equivalent to nearly 85 cwt. of crystallized sugar. They are furnished with steam-cocks and waste steam-pipes. Under the level of the spheroids *d, d*, the horizontal main pipe is seen, for supplying the cases with steam. In the face of each pan, above the line *b, b*, the handle of the proof-stick appears, like that of a stop-cock. The distribution of the measure cisterns, and some other parts of the pans, is



slightly varied in this representation from the former. From the bottom of the liquor cisterns *c, c*, pipes descend to the charging measures *a, a*, below. The cisterns *c, c*, are made of copper, and contain each about 400 gallons. Six tons of refined sugar can be turned out daily in a three-pan house.

Fig. 1399. represents in section another form of the vacuum-pan. *a* is the spheroidal copper vessel, supported by four iron columns *b, b*. It may be discharged by means of

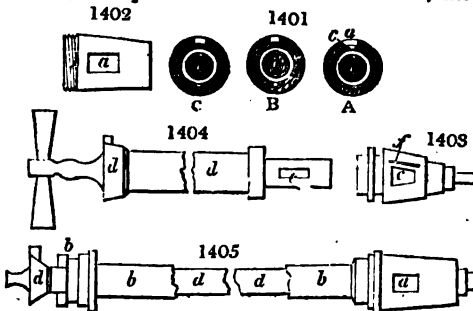


the pipe *e*, which is secured with a conical valve *d*. This may be opened or shut, by acting on the lever *e*. The lower of the two hemispheres of which the pan is composed is double, and the interstitial space *f, f*, is filled with steam by the pipe *g*, as the heating and evaporating agent. *h*, is the steam valve; *i*, the pipe for the efflux of the condensed water. *k*, a tube for the escape of the air at the commencement of the operation. *l* is an apparatus inserted air-tight into the cover of the vacuum-pan, and which dips down into the syrup; serving to take out a sample of it, without allowing air to enter, and hence called the proof-stick. The construction of this instrument is exhibited in *figs.* 1401, 1402, 1403, 1404, 1405, which will be presently explained. *m*, is the thermometer, which is also plunged into the sugar; behind it, is the barometer. *n*, is the charger or gauge-vessel, filled with the filtered syrup, which it discharges by the pipe *n'*. *o*, is the cover or capital of the vacuum-pan. *o'*, is a safety-valve, through which the air may be admitted after the completion of the process. *p*, is a bent pipe, slanting downwards, with a stopcock *g*, at its end, to receive the superfluous syrup. The vapour, which is disengaged from the syrup during its concentration, is extracted from the top of the pan into the pipe *r*, passes from this into the vessel *s*, which is divided by a plate of

copper into two compartments. The syrup forced over accidentally in the ebullition, goes into the vessel *s*, and passes by the glass tube *t*, into the pipe *p*. The glass tube serves to show the quantity of the syrup that has boiled over, so that it may be drawn off when necessary. For this purpose, the stopcock *u*, of the vessel *v*, must be closed, and *q* must be opened, in order to fill *v*, while the air contained in it escapes into the pan. The stopcock *q*, being then shut, and *u*, with the little air-cock *x*, opened, the syrup will flow into the large receiver placed beneath it, commonly but erroneously called a cooler; because it is a double copper basin, with steam in the interstitial space. The hot steam rushes from *s*, into the cast-iron vessel *y*, where it is condensed. *x*, is a pipe for introducing the water of condensation through the copper rose *a'*. The condensed water flows through the pipe *b'*, and the valve *e'*, to the air-pump, which receives motion from the shaft of the steam-engine.

The vacuum-pan was originally heated solely by the admission of steam between the double bottom; but of late years the heat has been also applied to the syrup through several coils of pipe placed within the pan, filled with steam at a temperature many degrees above 212° F., sometimes so high as 250°. By this double application of heat, the evaporating power of a pan has been vastly increased. The latest made pans have a considerably flat bottom, *fig.* 1400; a spiral pipe, laid close upon it; and between the under hemisphere and the upper one, there is a space *a, a*, 2½ feet high, to give the syrup room for frothing up without boiling over. The space *b*, of the bottom receives steam of common pressure, and the spiral tubes, of high pressure. Pans like this have been made for a house in London, which work off 16 tons of sugar-lobes daily.

The proof-stick, *fig.* 1405, consists of a cylindrical rod, capable of being screwed air-tight into the pan in an oblique direction downwards. The upper or exterior end is open; the under, which dips into the syrup, is closed, and has on one side a slit *a* (*figs.* 1401, 1402) or notch, about ¼ inch wide. In this external tube, there is another shorter tube *b*, capable



of moving round in it, through an arc of 180°. An opening upon the under end *e*, corresponds with the slit in the outer tube, so that both may be made to coincide, *fig.* 1401. *A.* A wooden plug *d*, is put in the interior tube, but so as not to shut it entirely. Upon the upper end there is a projection or pin, which catches in a slit of the inner tube, by which this may be turned round at pleasure. In the lower end of the plug there is a hole *e*, which

can be placed in communication with the lateral openings in both tubes. Hence it is possible, when the plug and the inner tube are brought into the proper position, *A*, *fig.* 1401., to fill the cavity of the wooden rod with the syrup, and to take it out without allowing any air to enter. In order to facilitate the turning of the inner tube within the outer, there is a groove in the under part, into which a little grease may be introduced.

Whenever a proof has been taken, the wooden plug must be placed in reference to the inner tube as shown in *fig.* 1401. *c*, and then be turned into the position *A*; when the cavity of the plug will again be filled with syrup. *c* must be now turned back to the former position, whereby all intercourse with the vacuum-pan is cut off; the plug being drawn out a little, and placed out of communication with the inner tube. The plug is then turned into the position *B*, drawn out, and the proof examined by the fingers.

Table showing the boiling point of syrup, at the corresponding atmospheric pressure within the vacuum-pan: —

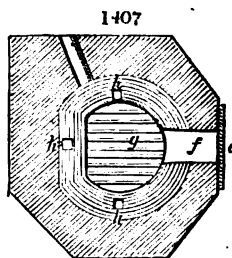
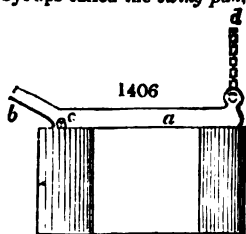
Height of the mercury (inches) in one leg of the syphon, above that in the other —:

| | | | | | | | | | | | | |
|------|------|-----|------|------|------|------|------|------|------|------|------|-------|
| 0.74 | 0.86 | 1.0 | 1.17 | 1.36 | 1.57 | 1.80 | 2.05 | 2.36 | 2.72 | 3.10 | 3.52 | 4.00. |
|------|------|-----|------|------|------|------|------|------|------|------|------|-------|

Boiling point, Fahr. —
 115° 120° 125° 130° 135° 140° 145° 150° 155° 160° 165° 170° 175°.

The large double steam-basin, which receives several successive skippings of the concentrated granulating syrup, serves to heat it from the temperature of 160° or 170°, at which it leaves the vacuum-pan, up to 200° or thereby, before it is filled out into the moulds; for were it introduced in the cooler state, it would not concrete into sufficiently compact loaves.

The following apparatus is used in many French sugar-houses, for concentrating syrups called the *swing pan*, or *chaudière à bascule*. It is represented in *fig. 1406*, in elevation, and in *fig. 1407*, in ground plan. *a* is the pan; *b*, its spout; *c*, the axis round which it swings, so as to empty itself, when raised behind by the chain *d*; *e* is the furnace door; *f*, the passage to the fireplace and grate *g*; *h, h*, side flues for conducting the smoke into the chimney.

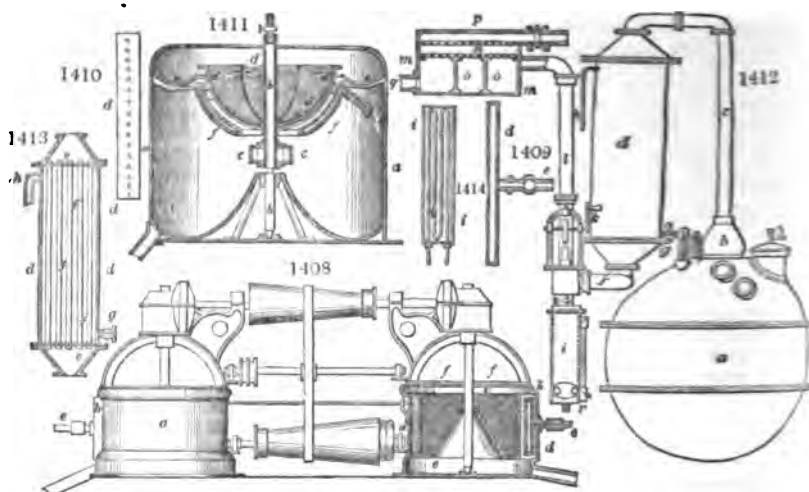


The duly clarified, concentrated, granulated, and reheated syrup, is transferred, by means of copper basins from the coolers into conical moulds, made only of brown and somewhat porous earthenware, or of sheet iron, strongly painted. The sizes of the moulds vary, from a capacity of 10 pound *loaves* to that of 56 pound *bastards*—a kind of soft brown sugar obtained by the concentration of the inferior syrups. These moulds have the orifices at their tips closed with bits of twisted paper, and are set up in rows close to each other, in an airy apartment adjoining the coolers. Here they are left several hours, commonly the whole night, after being filled, till their contents become solid, and they are lifted next morning into an upper floor, kept at a temperature of about 80° by means of steam pipes, and placed each over a pot to receive the syrup drainings—the paper plug being first removed, and a steel wire, called a piercer, being thrust up to clear away any concretion from the tip. Instead of setting the lower

portion of the inverted cones in pots, some refiners arrange them in wooden racks, with their apices suspended over longitudinal gutters of lead or zinc, laid with a slight slope upon the floor, and terminating in a sunk cistern. The syrup which flows off spontaneously is called green syrup. It is kept separate. In the course of two or three days, when the drainage is nearly complete, some finely clarified syrup, made from loaf sugar, called *liquor* by the refiners, is poured to the depth of about an inch upon the base of each cone, the surface having been previously rendered level and solid by an iron tool, called a bottoming trowel. The liquor, in percolating downwards, being already a saturated syrup, can dissolve none of the crystalline sugar, but only the coloured molassy matter; whereby, at each successive liquoring, the loaf becomes whiter, from the base to the apex. A few moulds, taken promiscuously, are emptied from time to time, to inspect the progress of the blanching operation; and when the loaves appear to have acquired as much colour, according to the language of refiners, as is wanted for the particular market, they are removed from the moulds, turned on a lathe at the tips, if necessary, set for a short time upon their bases, to diffuse their moisture equally through them, and then transferred into a stove heated to 130° or 140° by steam pipes, where they are allowed to remain for two or three days, till they be baked thoroughly dry. They are then taken out of the stove, and put up in blue paper for sale.

In the above description of sugar-refining, I have said nothing of the process of claying the loaves, because it is now nearly obsolete, and abandoned in all well-appointed sugar-houses. Those of my readers who desire to become acquainted with sugar-refining upon the old plan, may consult my Report made upon the subject to the Honourable House of Commons in July 1833; where they will find every step detailed, and the numerical results stated with minute accuracy. The experiments subservient to that official report were instituted purposely to determine the average yield or product, in double and single refined loaves, lumps, bastards and treacle, which different kinds of sugar would afford per cwt., when refined by decolouring with not more than 5 per cent. of bone black, boiling in an open pan, and clearing the loaves with clay-pap.

Centrifugal action has been of late years had recourse to for separating the uncrystallizable from the granular portion of sugar; and the following mode of applying it seems to be one of the most efficacious. It was patented in October 1849, by Mr. C. W. Finsel, of Bristol. *Fig. 1408*, is an elevation, partly in section; *fig. 1409*, is a vertical section, and *fig. 1410*, a front view (both on a larger scale than *fig. 1406*.) of the perforated box, by



which steam is caused to act against the periphery of the cylinder or drum of the machine.

In the outer case *a*, a narrow recess *b*, of nearly the same height as the revolving cylinder *c* is formed; and in this recess is placed the steam box *d*, connected by a pipe *e*, with a steam boiler. The side of the box *d*, which is nearest to the cylinder *c*, is perforated with small holes, through which the steam rushes in numerous jets against the periphery of the cylinder *c*; and such steam is prevented from escaping from the machine by the application of lids *f*, to the top of the case *a*.

The mode of operating with the machine is as follows:—

The sugar having been mixed with molasses or syrup, to bring it to the proper consistency, is put in the cylinder *c*, which is then caused to rotate; and after the cylinder has made a few turns, the steam is let on (by turning a cock on the pipe *e*), and permitted to issue freely through the holes in the box *d*, against the periphery of the cylinder for about a minute, which has the effect of clearing the meshes. The state of the sugar may be ascertained, from time to time, without stopping the machine, by raising the lids *f*; and if the extraction of the moisture therefrom appears to be impeded, steam is to be again let on for a short time, in order to clear the meshes. The cylinder *c* is to be kept rotating, and the steaming repeated occasionally (if required) until the whole or nearly the whole of the syrup or fluid is extracted from the sugar; and this, when operating upon ordinary sugar, will generally be effected in a few minutes. Sugars taken from the evaporating pan, after partial cooling, may be put into the machine, and operated upon directly, as above.

The apparatus, *fig.* 1411., is for working such sugars as require to be previously mixed with liquid. It consists of a vessel with a series of steam-pipes fixed in it; and of a centrifugal sieve and centrifugal drum, both fixed upon the same shaft, which revolves in the vessel. *a* is the vessel, in the centre of which a vertical shaft *b*, is mounted. This shaft for about two-thirds of its length from the top is made hollow; and upon it is fixed a small centrifugal drum *c*, having a perforated periphery, and furnished with divisions or leaves, projecting inwards, to impart to the fluid (which enters it through openings in the shaft *b*), the centrifugal speed of the shaft. The shaft *b* also carries a sieve *d*, the meshes of which are made coarser or finer at pleasure; and for breaking any accretions of crystals the sieve is furnished with a number of metal points. A receptacle *e*, is formed at the upper part of the vessel, to receive any lumps that may happen to be thrown over the top of the sieve. Beneath the sieve several perforated steam pipes *f*, are fixed for the purpose of causing steam to be brought in contact with the particles of sugar which pass through the sieve. Thus:—Communicate motion to the shaft *b*, and admit steam to the pipes *f*, through the pipe *e*, then introduce the syrup with which the sugar is to be mixed into the drum *c*, through the shaft *b*. The sugar which has been prepared by crushing is deposited in the centre of the sieve, whence it is thrown by the centrifugal action through the meshes of the sieve; it then descends through the steam that issues from the pipes *f*, whereby it is moistened and prepared to receive the syrup, which is thrown from the drum *c*, and thus become mixed with the sugar.

Fig. 1412. is an elevation, partly in section, of a vacuum-pan, with the improved apparatus applied thereto. *a*, is the vacuum-pan, the head *b*, of which is connected by a copper pipe *c*, with a condenser *d*, — shown in vertical section at *fig.* 1413. The condenser consists of a metal cylinder with conical ends, which are separated from the body of the cylinder by plates *e*; but a communication is established between the two ends by a series of copper pipes *f*, which are inserted at top and bottom into the plates *e*. At the bottom of the cylinder there is a pipe *g*, by which cold water is admitted into it; and at the top there is a pipe *h*, through which the water flows away. The bottom of the condenser is connected with a receiver *i*, by a pipe *j*, provided with a stop-valve, which can be worked by means of the crank-handle *k*. The receiver is furnished with steam-pipes *i*¹, for evaporating the water of condensation, as represented at *fig.* 1414. — which is a plan-view of the receiver *i*, with the top removed. The receiver is connected by a pipe *l*, with a second condensing vessel *m*, which is divided longitudinally, near the top, by a perforated plate *n*, supported by vertical bearers *o*. There is a perforated pipe *p*, at the top of the condenser *m*, by which cold water is supplied to the upper compartment thereof, whence it descends in a shower through the perforations in the plate *n*, and condenses the aqueous vapour in the lower compartment. The condenser *m*, is connected with the exhausting pumps by the pipe *q*.

The progress of the operation is as follows:— As the vapour from the vacuum-pan

Products of refining in Bond. Refinery A.

| Foreign sugar received into refinery | Cwt. qr. | Delivered for exportation stores, &c. :— | Cwt. qr. lb. |
|--------------------------------------|-------------|--|--------------|
| British refined, ditto | 47,479 3 14 | Refined sugar | 28,993 1 10 |
| | 340 0 0 | Bastards | 7,306 1 27 |
| | 47,719 3 14 | Treacle | 96,44 2 8 |
| 28993 1 10 | | Raw sugar removed to other refinery | 385 2 14 |
| 7306 1 27 | | Syrup, ditto | 284 1 7 |
| 9644 2 8 | | Scrappings, ditto | 143 0 10 |
| 45944 1 17 | | Samples | 14 0 23 |
| 45944 1 17 | | Total | 46,773 2 15 |
| 946 | | Deficiency | 946 0 27 |
| 46890 1 17 | | Balance | 47,719 3 14 |
| 240 | | | |
| 47130 1 17 | | | |

Refinery B.

| Foreign sugar received into refinery | Cwt. qr. lb. | Delivered for exportation stores, &c. :— | Cwt. qr. lb. |
|--------------------------------------|--------------|--|--------------|
| British refined (bastard) | 56,485 1 22 | Refined sugar | 41,770 0 26 |
| | 314 0 21 | Bastards | 1,425 3 4 |
| | 56,799 2 15 | Treacle | 12,194 2 4 |
| 56800)41770 (73·5 | | Total | 55,390 2 6 |
| 30760 2·5 | | Deficiency | 1,409 0 9 |
| 2100 2·5 | | Balance | 56,799 2 15 |
| 90100 21·5 | | | |
| 17040 — | | | |
| 100·0 | | | |
| 3060 | | | |
| 56800)1426 (2·5 | | | |
| 1136 | | | |
| 2900 | | | |
| 56800)121950 (21·4 or 5 | | | |
| 113600 | | | |
| 83500 | | | |
| 56800 | | | |
| 26700 | | | |
| 56800)140900 (3·5 | | | |
| 11360 | | | |
| 27300 | | | |

passes through the condenser *d*, a portion of it is condensed in the pipes *f*, together with the saccharine matters, and flows from the bottom of the condenser into the receiver *i*, in the state of a weak solution of sugar. Steam being admitted into the pipes *g*, the heat thereof (in combination with the action of the exhausting pumps) evaporates the solution to a more concentrated state; and then it may be drawn off through the pipe *r*; — air being at the same time admitted into the receiver through a cock at *s*, to supply the place of the liquor as it flows away. If the pumps are kept in action during this part of the process, a throttle-valve must be used to close the pipe *l*.

Refinery C.

| Foreign sugar received | Cwt. | qr. | lb. | Delivered for exportation stores, &c. | Cwt. | qr. | lb. |
|------------------------|-------|-----|-----|--|-------|-----|-----|
| | 8,074 | 0 | 2 | | | | |
| 44,047 | | | | Refined sugar | 4,396 | 1 | 11 |
| 22 | | | | Bastards | 1,775 | 1 | 15 |
| 107 | | | | Treacle | 855 | 3 | 7 |
| | | | | Samples | 2 | 0 | 21 |
| 874 | | | | Total | 7,030 | 0 | 26 |
| 126 | | | | Deficiency* | 1,043 | 3 | 5 |
| | | | | Balance | 8,074 | 0 | 2 |

* *Mem.*— An accident happened by the bursting of the boiler.

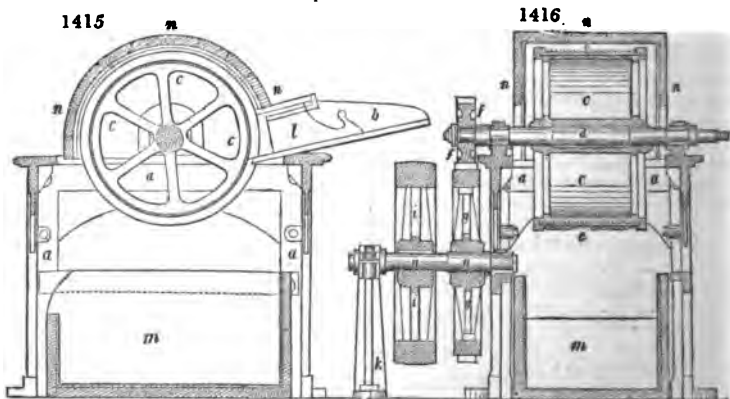
BEET-ROOT SUGAR.

The physical characters which serve to show that a beet-root is of good quality, are its being firm, brittle, emitting a creaking noise when cut, and being perfectly sound within; the degree of sweetness is also a good indication. The 45th degree of latitude appears to be the southern limit of the successful growth of beet in reference to the extraction of sugar.

Extraction of Sugar from the Beet.— The first manipulations to which the beets are exposed, are intended to clear them from the adhering earth and stones, as well as the fibrous roots and portions of the neck. It is desirable to expose the roots, after this operation, to the action of a cylinder washing-machine.

The parenchyma of the beet is a spongy mass, whose cells are filled with juice. The cellular tissue itself, which forms usually only a twentieth or twenty-fifth of the whole weight, consists of ligneous fibre. Compression alone, however powerful, is inadequate to force out all the liquor which this tissue contains. To effect this object, the roots must be subjected to the action of an instrument which will tear and open up the greatest possible number of these cells. Experiments have, indeed, proved, that by the most considerable pressure, not more than 40 or 50 per cent. in juice from the beet can be obtained; whilst the pulp procured by the action of a grater produces from 75 to 80 per cent.

The beet-root rasp of Moulfarine is represented in *figs.* 1415, 1416. *a, a*, is the frame-



work of the machine; *b*, the feed-plate made of cast iron, divided by a ridge into the

parts; *c*, the hollow drum; *d*, its shaft, upon either side of whose periphery nuts are screwed for securing the saw blades *e, e*, which are packed tight against each other by means of laths of wood; *f*, is a pinion upon the shaft of the drum, into which the wheel *g* works, and which is keyed upon the shaft *h*; *i*, is the driving rigger; *k*, pillar of support; *l*, blocks of wood, with which the workman pushes the beet-roots against the revolving-rasp; *m*, the chest for receiving the beet-pap; *n*, the wooden cover of the drum, lined with sheet iron. The drum should make 500 or 600 turns in the minute.

A few years ago, M. Dombasle introduced a process of extracting the juice from the beet without either rasping or hydraulic pressure. The beets were cut into thin slices by a proper rotatory blade-machine; these slices were put into a macerating cistern, with about their own bulk of water, at a temperature of 212° F. After half an hour's maceration, the liquor was said to have a density of 2° B., when it was run off into a second similar cistern, upon other beet-roots; from the second it was let into a third, and so on to a fifth; by which time, its density having risen to $5\frac{1}{2}^{\circ}$, it was ready for the process of defecation. Juice produced in this way is transparent, and requires little lime for its putrefication; but it is apt to ferment, or to have its granulating power impaired by the watery dilution. The process has been accordingly abandoned in most establishments.

I have seen the following operations successfully executed in a beet-root factory near Lille, and have since verified their propriety in my own laboratory upon white beets, grown near Mitcham in Surrey. My product was nearly 5 per cent.; it was very fair, and large grained, like the vacuum-pan sugar of Demerara, but without its clamminess.

The roots were washed by a rotary movement upon a grating made like an Archimedes' screw, formed round the axis of a squirrel-cage cylinder, which was laid horizontally beneath the surface of water in an oblong trough. It was turned by hand rapidly, with the intervention of a toothed wheel and pinion. The roots, after being sufficiently agitated in the water, were tossed out by the rotation at the end of the cylinder furthest from the winch. They were next hoisted in a basket up through a trap-hole into the floor above, by means of a cord and pulley moved by mechanical power; a six-horse steam engine, upon Woolfe's expansive principle, being employed to do all the heavy work. They were here subjected to the mechanical grater (*râpe mécanique*), see *fig.* 1415, 1416., which had, upon its sloping feed-table, two square holes for receiving at least two beets at a time, which were pushed forwards by a square block of wood held in the workman's hand by means of a strap. The rasp was a drum, having rows of straight saws placed half an inch apart around its periphery, *parallel to the axis*, with teeth projecting about $\frac{1}{4}$ of an inch. The space between each pair of saws was filled with a wedge of wood. The steel slips, or saw plates, were half an inch broad, twelve inches long, and serrated on both their longitudinal edges, so that when the one line of teeth was blunted, the other could be turned out. The drum made 750 turns per minute.

The pulp from the rasp fell into a flat trough placed beneath, whence it was shovelled into small bags. Each bag had its mouth folded over, was laid upon a wicker plate, and spread flat with a rolling-pin. The bags and hurdles were then piled in the hydraulic press. There were three presses, of which the two allotted to the first pressure were charged alternately, and the third was reserved for a final and more durable pressure of the *marc*. See PRESS, HYDRAULIC, and STEARINE PRESS.

The juice flowed over the edges of the wicker plates, and fell into the sill-plate of the press, which was furnished with upright borders, like a tray, through whose front side a pipe issued, that terminated in a leathern hose, for conducting the juice into an elevated cistern in the boiling-house. Here one pound of slaked lime was mixed with every four hectolitres (about 88 gallons imp.) of juice. The mixture was made to boil for a little while in a round pan alongside, whence it was decanted into oblong flat filters, of blanket stuff. The filtered liquor, which had in general a spec. gravity of 15° Baumé (about double that of the fresh juice), was now briskly concentrated by boiling, in an oblong pan, till it acquired the density of 28° B. The fire being damped with raw coal, the syrup was run off rapidly by a stopcock into a large basin with a swing handle, and immediately replaced by fresh defecated liquor. The basin was carried by two men to the opposite side of the boiling-house, and emptied into a cistern set on a high platform, whose horizontal discharge-pipe was provided with a series (five) of stopcocks, placed respectively over five copper chests (inverted truncated pyramids), containing a thick bed of granular bone black, covered with a perforated copper plate. The hot syrup thus filtered had a pale straw-colour, and was subsequently evaporated in swing pans, *figs.* 1406, 1407., over a brisk fire, in quantities equivalent to half a cwt. of sugar, or four hectolitres of average juice.

MAPLE SUGAR.

The manufacture of sugar from the juice of a species of maple trees, which grow
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spontaneously in many of the uncultivated parts of North America, appears to have been first attempted about 1752, by some of the farmers of New England, as a branch of rural economy.

The sugar maple, the *Acer saccharinum* of Linnæus, thrives especially in the states of New York and Pennsylvania, and yields a larger proportion of sugar than that which grows upon the Ohio. It is found sometimes in thickets which cover five or six acres of land; but it is more usually interperered among other trees. They are supposed to arrive at perfection in forty years.

The extraction of maple sugar is a great resource to the inhabitants of districts far removed from the sea; and the process is very simple. After selecting a spot among surrounding maple trees, a shed is erected, called the *sugar-camp*, to protect the boilers and the operators from the vicissitudes of the weather. One or more augers, three-fourths of an inch in diameter; small troughs for receiving the sap; tubes of elder or sumach, 8 or 10 inches long, laid open through two-thirds of their length, and corresponding in size to the auger-bits; pails for emptying the troughs, and carrying the sap to the camp; boilers capable of holding 15 or 16 gallons; moulds for receiving the syrup inspissated to the proper consistence for concreting into a loaf of sugar; and, lastly, hatchets to cut and cleave the fuel, are the principal utensils requisite for this manufacture. The whole of February and beginning of March are the sugar season.

The trees are bored obliquely from below upwards, at 18 or 20 inches above the ground, with two holes 4 or 5 inches asunder. Care must be taken that the auger penetrates no more than half an inch into the alburnum, or white bark; as experience has proved that a greater discharge of sap takes place at this depth than at any other. It is also advisable to perforate in the south face of the trunk.

The trough, which contains from two to three gallons, and is made commonly of white pine, is set on the ground at the foot of each tree, to receive the sap which flows through the two tubes inserted into the holes made with the auger; it is collected together daily, and carried to the camp, where it is poured into casks, out of which the boilers are supplied. In every case, it ought to be boiled within the course of two or three days from flowing out of the tree, as it is liable to run quickly into fermentation, if the weather become mild. The evaporation is urged by an active fire, with careful skimming during the boiling; and the pot is continually replenished with more sap, till a large body has at length assumed a syrupy consistence. It is then allowed to cool, and passed through a woollen cloth, to free it from impurities.

The syrup is transferred into a boiler to three-fourths of its capacity, and it is urged with a brisk fire, till it acquires the requisite consistence for being poured into the moulds or troughs prepared to receive it. This point is ascertained, as usual, by its exhibiting a granular aspect, when a few drops are drawn out into a thread between the finger and the thumb. If in the course of the last boiling, the liquor froth up considerably, a small bit of butter or fat is thrown into it. After the molasses have been drained from the concreted loaves, the sugar is not at all deliquescent, like equally brown sugar from the cane. Maple sugar is in taste equally agreeable with cane sugar, and it sweetens as well. When refined it is equally fair with the loaf sugar of Europe.

The period during which the trees discharge their juices is limited to about six weeks. Towards the end of the flow, it is less abundant, less saccharine, and more difficult to be crystallized. See POTATO SUGAR.

SUGAR OF POTATOES, GRAPES, OR STARCH. About eight years ago a sample of sweet mucilaginous liquid was sent to me for analysis, by the Honourable the Commissioners of Customs. It was part of a quantity imported in casks at Hull, from Rotterdam. It was called by the importers, "Vegetable Juice." I found it to be imperfectly saccharified starch or fecula; and, on my reporting it as such, it was admitted at a moderate rate of duty.

Some months after I received a sample of a similar liquid from the importer at Hull, with a request that I would examine it chemically. He informed me, that an importation, just made by him of 30 casks of it, had been detained by orders of the Excise, till the sugar duty of 25s. per cwt. of solid matter it contained was paid upon it. It was of specific gravity 1.362, and contained 80 per cent. of ill-saccharified fecula.

In the interval between the first importation and the second, an Act of Parliament had been obtained for placing every kind of sugar, from whatever material it was formed, under the provisions of the "Beet-root Sugar Bill." As the saccharometer tables, subservient to the levying of the excise duties, under this Act, were constructed by me, at the request of the President of the Board of Trade, I well know that 50 per cent. of the syrup of the beet-root was deducted as a waste product, because beet-root molasses is too crude an article for the use of man. Well saccharified starch paste, however, constitutes a syrup, poor indeed in sweetness when compared with cane syrup, or that of the beet-root; but then it does not spontaneously blacken into molasses, by

evaporation, as solutions of ordinary sugar never fail to do when they are concentrated, even with great care. Hence the residuary syrups of saccharified fecula may be all worked up into a tolerably white granular mass, which, being crushed, is used by greedy grocers to mix with their dark-brown bastard sugars, to improve their colour.

It is only within a few years that sugar has been in this country manufactured from potato starch to any extent, though it has been long an object of commercial enterprise in France, Belgium, and Holland, where the large coarse potatoes are used for this purpose. The raw material must be very cheap there as well as the labour; for potato flour or starch, for conversion into sugar, has been imported from the continent into this country in large quantities, and sold in London at the low price of 10s. per cwt.

The process usually followed by the potato sugar makers, is to mix 100 gallons of boiling water with every 112 lbs. of the fecula, and 9 lbs. of the strongest sulphuric acid. This mixture is boiled about 12 hours in a large vat, made of white deal, having pipes laid along its bottom, which are connected with a high pressure steam-boiler. After being thus saccharified, the acid liquid is neutralized with chalk, filtered, and then evaporated to the density of about 1.300, at the boiling temperature, or exactly 1.342, when cooled to 60°. When syrup of this density is left in repose for some days, it concretes altogether into crystalline tufts, and forms an apparently dry solid, of specific gravity 1.39. When this is exposed to the heat of 220°, it fuses into a liquid nearly as thin as water; on cooling to 150°, it takes the consistence of honey, and at 100° F. it has that of a viscid varnish. It must be left a considerable time at rest before it recovers its granular state. When heated to 270°, it boils briskly, gives off one-tenth of its weight of water, and concretes, on cooling, into a bright yellow, brittle, but very deliquescent mass, like barley sugar. If the syrup be concentrated to a much greater density than 1.340, as to 1.362, or if it be left faintly acidulous, in either case it will not granulate, but will remain either a viscid magma or become a concrete mass, which may indeed be pulverised, though it is so deliquescent as to be unfit for the adulteration of raw sugar. The Hull juice is in this predicament, and is therefore, in my opinion, hardly amenable to the new sugar law, as it cannot by any means be worked up into even the semblance of sugar.

Good Muscovado sugar, from Jamaica, fuses only when heated to 280°, but it turns immediately dark-brown, from the disengagement of some of its carbon, at that temperature, and becomes, in fact, the substance called "caramel" by the French, which is used for colouring brandies, white wines, and liqueurs.

Thus we see that starch or grape sugar is well distinguished from cane sugar, by its fusibility at a moderate heat, and its inalterability at a pretty high heat. Its sweetening power is only two-fifths of that of ordinary sugar. A good criterion of incompletely formed starch sugar is, its resisting the action of sulphuric acid, while perfectly saccharified starch or cane sugar is readily decomposed by it. If, to a strong solution of imperfectly saccharified grape sugar, nearly boiling hot, one drop of strong sulphuric acid be let fall, no perceptible change will ensue, but if the acid be dropped into solutions of either of the other two sugars, black carbonaceous particles will make their appearance.

The article which was detained by the Excise for the high duties at Hull, had not been affected by sulphuric acid, like the solutions of cane sugar, and of the well-made potato sugar of London; and for this reason I gave my opinion in favour of admitting the so-called vegetable juice at a moderate rate of duty.

I subjected the solid matter obtained by evaporating the said juice to ultimate analysis, by peroxide of copper, in a combustion tube, with all the requisite precautions, and obtained, in one experiment, 37 per cent. of carbon; and in another 38 per cent., when the substance had been dried in an air-bath, heated to 275°. The difference to 100, is hydrogen and oxygen, in the proportion to form water. Now this is nearly the constitution of starch. Cane sugar contains about 5 per cent. more carbon, whereby it readily evolves this black element, by the action of heat or sulphuric acid.

An ingenious memoir, by Mr. Trommer, upon the distinguishing criteria of gum, dextrine, grape sugar, and cane sugar, has been published in the 39th volume of the "Annalen der Chemie und Pharmacia." I have repeated his experiments, and find them to give correct results, when modified in a certain way. His general plan is to expose the hydrate of copper to the action of solutions of the above-mentioned vegetable products. He first renders the solution alkaline, then adds solution of sulphate of copper to it, and either heats the mixture or leaves it for some time in the cold. By pursuing his directions, I encountered contradictory results; but by the following method I have secured uniform success, in applying the criteria, and have even arrived at a method of determining, by a direct test, the quantity of sugar in diabetic urine.

I dissolve a weighed portion of sulphate of copper in a measured quantity of water, and make the solution faintly alkaline, as tested with turmeric paper, by the addition

of potash lye, in the cold; for if the mixture be hot, a portion of the disengaged green hydrate of copper is converted into black oxide. This mixture being always agitated before applying it, forms the test liquor. If a few drops of it be introduced into a solution of gum, no change ensues on the hydrate of copper, even at a boiling heat, which shows that a gummate of copper is formed, which resists decomposition; but the cupreous mixture, without the gum, is rapidly blackened at the boiling temperature. I do not find that the gummate is re-dissolved by an excess of water, as Trommer affirms.

Starch and tragacanth comport like gum, in which respect I agree with Trommer. Starch, however, possesses already a perfect criterion in iodine water. Mr. Trommer says that solution of dextrine affords a deep blue coloured liquid, without a trace of precipitate; and that when his mixture is heated to 85° C., it deposits red grains of protoxide of copper, soluble in muriatic acid. I think these phenomena are dependent, in some measure, upon the degree of alkaline excess in the mixture. I find that solution of dextrine, treated in my way, hardly changes in the cold; but when heated slightly, it becomes green, and by brisk boiling an olive tint is produced. It thus betrays its tendency of transition into sugar.

Solution of cane sugar, similarly treated, undergoes no change in the cold at the end of two days; and very little change of colour even at a boiling heat, if not too concentrated. Cane sugar, treated by Trommer in his way, becomes of a deep blue; it can be boiled with potash in excess, without any separation of orange-red oxide of copper.

Starch or grape sugar has a marvellous power of reducing the green hydrate of copper to the orange oxide. I find, however, that it will not act upon the pure blue hydrate, even when recently precipitated; it needs the addition, in every case, of a small portion of alkali. Yet ammonia does not seem to serve the purpose; for, in using the ammonia-sulphate of copper, in solution, I obtained unsatisfactory results with the above vegetable products.

The black oxide of copper is not affected by being boiled in solution of starch sugar. "If solution of grape sugar," says Trommer, "and potash, be treated with a solution of sulphate of copper, till the separated hydrate is re-dissolved, a precipitate of red oxide will soon take place, at common temperatures, but it immediately forms, if the mixture is heated. A liquid containing $\frac{1}{1000000}$ of grape sugar, even one-millionth part," says he, "gives a perceptible tinge (orange), if the light is let fall upon it." To obtain such a minute result, very great nicety must be used in the dose of alkali, which I have found it extremely difficult to hit. With my regulated alkaline mixture, however, I never fail in discovering an exceedingly small portion of starch sugar, even when mixed with Muscovado sugar; and thus an excellent method is afforded of detecting the frauds of the grocers.

I find that manna deoxidizes the green hydrate of copper slowly when heated, but not nearly to the same extent as grape sugar, which reduces it rapidly to the orange oxide.

If an excess of the hydrate of copper test be used, there will be a deposit of green hydrate at the bottom of the vessel, under the orange oxide.

To apply these researches to the sugar of diabetic urine:—This should first be boiled briskly to decompose the urea, and to dissipate its elements in the form of ammonia as well as to concentrate the saccharine matter, whereby the test becomes more efficacious. Then add to the boiling urine, in a few drops at a time, the cupreous mixture, containing a known quantity of sulphate of copper, till the whole assumes a greenish tint, and continue the heat until the colour becomes bright orange. Should it remain green, it is a proof that more hydrate of copper has been introduced than has been equivalent to the deoxidizing power of the starch sugar. I have found that one grain of sulphate of copper in solution, supersaturated very slightly with potash, is decomposed with the production of orange protoxide, by about 3 grains of potato sugar; or, more exactly, 30 parts of the said sulphate, in the state of an alkalinat of the hydrate of copper, pass altogether into the state of orange oxide, by means of 100 parts of granular starch sugar. Thus for every 3 grains of sulphate so changed, 10 grains of sugar may be estimated to exist in diabetic urine.

Acetate of copper may be used in the above experiments, but it is not so good as the sulphate. The chloride of copper does not answer.

Specific gravity is also an important criterion, applied to sugars that of the cane and beet-root is 1.577; that of starch sugar, in crystalline tufts, is 1.39, or perhaps 1.40, as it varies a little with its state of dryness. At 1.342, syrup of the cane contains 70 per cent. of sugar; at the same density, syrup of starch sugar contains $75\frac{1}{2}$ per cent. of concrete matter, dried at 260° F., and therefore freed from the 10 per cent. of water which it contains in the granular state. Thus, another distinction is obtained between the two sugars, in the relative densities of their solutions, at like saccharine contents per cent.

A very simple method of improving the quality of sugar has been proposed by Messrs. Oxland, of Plymouth, chemists, for defecating the juice of beet-root and of the cane. It consists in the use of acetate of alumina, of which they say that four pounds of the earth dissolved in acetic acid are sufficient for 1 ton of Jamaica sugar, without any peculiarity of treatment in the boiling or filtration. I should fear that the acid might be apt to weaken the grain or crystalline force of the sugar. When nearly all the acetic acid is driven off by the boiling of the syrup, a solution of tan, made by digesting 1 pound of crushed valonia in 2 gallons of hot water, is filtered hot into the syrup.

Fermentable property of different kinds of Sugar. There is a remarkable difference between the fermentable property of cane sugar and grape sugar, which has not hitherto been sufficiently noticed, no mention being made of it in chemical works. It is, that a solution of grape sugar requires but a very small quantity of ferment to induce alcoholic fermentation, while solution of cane sugar requires a large quantity. When a solution is made of the same quantities of cane sugar and grape sugar in equal proportions of distilled water, it will be necessary to add at least eight times as much of the same ferment to induce alcoholic fermentation in the solution of cane sugar as in that of grape sugar.

Under the action of a larger quantity of ferment, cane sugar is transformed into grape sugar, and this latter appears to be the only substance susceptible of being decomposed by ferment into carbonic acid and alcohol.

If a solution of cane sugar be brought into the state of alcoholic fermentation, and the action be stopped some time before the decomposition of the sugar is completed, by the addition of a large quantity of strong alcohol, it will be found that the remaining undecomposed sugar has been transformed into grape sugar.

The fermentable property of sugar depends then upon the same causes as that of starch, several kinds of gum, and sugar of milk. These substances are transformed into grape sugar under the influence of different agents; but of all vegetable matters susceptible of undergoing this transformation, grape sugar is undoubtedly that in which the change is effected with the greatest ease and promptitude. Indeed, it so readily undergoes the alcoholic fermentation that it has been classed among fermentable sugars, but it has no more right to this title than starch, several kinds of gum, and sugar of milk.

Another invention of Messrs. Oxland for improvements in the manufacture and refining of sugar, (patented in May, 1851) consists in the use of phosphoric acid in a combined state for defecating saccharine liquids, or solutions of sugar, and removing the colour of the same. On the 26th of April, 1849, the present patentees obtained a patent for defecating and removing the colour from solutions of sugar by the employment of acetate of alumina. In the specification of such patent, lime was directed to be used for effecting the separation of the alumina; but it has been found that, even when care is observed, some alumina is liable to be left in solution. When acetate of alumina and lime have been used, the patentees effect the removal of the remaining alumina by the use of superphosphate of alumina or superphosphate of lime, by simply adding a small quantity of either of these substances to the syrup after the completion of the process with acetate of alumina, as described in the former specification, then boiling for two or three minutes, carefully neutralizing the excess of acid, by the addition of aluminate of lime, saccharate of lime, lime water, or milk of lime; and, when it has been ascertained that alumina is completely separated, completing the process in the manner described in the former specification.

In place of using acetate of alumina, either alone or combined with phosphoric acid, as above explained, phosphates may be employed directly; and they are capable of producing similar effects to those resulting from the use of acetate of alumina, with the advantage that the whole of the agent employed is separated from the saccharine matters. In treating a saccharine liquid, or solution of sugar, (say, for example, an ordinary sample of Mauritius sugar), the patentees dissolve it by blowing-up with steam in the usual way, but avoiding the use of blood, and adding a soluble phosphate to the water employed; if crystallized phosphate of soda be used, it should be in the proportion of one pound and a half thereof for each ton of sugar. The saccharine liquid is brought to the boiling point,—any acidity being neutralized with aluminate of lime, saccharate of lime, lime water, or milk of lime; and then the syrup thus obtained (which will be of the specific gravity of from 25° to 30° Baumé) is passed through the ordinary bag-filters. The sugar is, by this means, thoroughly defecated,—the feculent matters being left in the bags, from which the last trace of sugar may be removed by passing clean water through them. The weak solutions obtained in this way may be used for blowing up fresh quantities of raw sugar. As part of the colour is removed from the syrup by the above described operation, it may be considered sufficient treatment previous to boiling in the vacuum-pan, or otherwise, for crystalliza-

tion; but a further amount of colour may be removed by the use of from 5 to 8 per cent., or more, of hydrate of alumina (which has been dried at a temperature of 212° Fahr.) diffused through the water used in blowing up the sugar; and, by this means, the use of animal charcoal will be rendered unnecessary. The residuary alumina left in the filter bags, after the whole of the saccharine matter has been washed out, may be dried, and the organic matter removed by ignition; and, after further washing, to remove any residuary soluble saline substance, it may be employed for manufacturing hydrate or superphosphate of alumina; or, after the first-mentioned washing, previous to ignition, it may be used over again, with the addition of a further quantity of hydrate of alumina.

When superphosphate of alumina is used, it is mixed, in solution, with the water used in blowing-up the raw sugar, in the proportion of six pounds of alumina dissolved in phosphoric acid for each ton of sugar; and while the syrup (at from 25° to 30° Baumé) is being brought to the boiling point, any acidity is neutralized by the addition of aluminate of lime, saccharate of lime, lime water, or milk of lime. The syrup is then passed through bag-filters, and the clear syrup conducted into the receiver that supplies the vacuum or other boiling pan. The subsequent operations are the same as in the old plan of working. The matters left in the filter-bags are treated as above described, to remove any remaining saccharine matter.

The patentees prepare the superphosphate of alumina by dissolving alumina in phosphoric acid, in the following manner:—They burn bones white, grind them to fine powder, and digest the product in sufficient muriatic acid for the solution of the carbonate of lime only; and then they dry the residue, after carefully washing it, to remove every trace of soluble matter. To a given weight of this residue, mixed with enough water to make a thin paste (in a shallow earthenware tank or vessel), they add a quantity of pure sulphuric acid, sufficient to combine with nearly all the lime present, *i. e.* all except 2 or 3 per cent.; stirring the mixture well and keeping it warm (say above 90° Fahr.), for about 24 hours, and after this they lixiviate the mass with water until all the soluble matters are separated from the sulphate of lime. The strong liquors, obtained in this way, may be used for combining with alumina, and the weak solutions for lixiviating fresh quantities of phosphoric acid in course of manufacture. When alumina is digested in the phosphoric acid, produced in the manner above described, phosphate of alumina, insoluble in water, is first formed; and by dissolving this in a quantity of phosphoric acid sufficient only for that purpose, superphosphate of alumina is obtained, which should be filtered previous to use.

Aluminate of lime is prepared by dissolving alumina in caustic potash or soda, and then, by the addition of lime water or milk of lime, precipitating aluminate of lime, which is to be carefully washed. When required for use, the patentees diffuse the aluminate of lime through water, and they prefer to employ it instead of saccharate of lime, or milk of lime or lime water.

When making sugar from the cane, they defecate the juice with aluminate of lime in the usual way, neutralizing any excess of lime with superphosphate of alumina or superphosphate of lime; then, after filtering and concentrating the filtered liquid to from 25° to 30° Baumé, they treat the syrup with phosphate of soda, in the same manner as described with respect to raw sugars; and, after a second filtration, they boil in the usual way.

In the manufacture and refining of beet-root sugar, they proceed as above described for cane sugar, only using a larger quantity of aluminate of lime or milk of lime in the first defecation.

The patentees state that they do not confine themselves to the details above given, or to the phosphates mentioned, as others may be substituted; but what they claim is, the employment of phosphoric acid in a combined state, as above described. — *Newton's Journal*, vol. xl. p. 27.

Sugar tested by bichromate of potash. If a thick pure cane sugar syrup be mixed with a boiling solution of bichromate of potash in a test tube, and then withdrawn from the heat, a deep green colour will appear, especially on dilution with water. Other kinds of sugar remain indifferent to the bichromate. No change takes place in it with starch sugar, and if this be mixed with cane sugar, it protects the latter from being coloured a dark green. Nitrate of cobalt added to cane sugar alkalinized produces a bluish violet precipitate; but not with an alkalinized (potash) grape sugar. — *Reich*.

SUGAR in Four Ports of GREAT BRITAIN, for the Ten Months ending 31st October, 1851 and 1852.

| | IMPORT. | | DUTY PAID. | | EXPORT. | | STOCK. | |
|------------------------------------|----------------|----------------|----------------|----------------|---------------|---------------|----------------|----------------|
| | 1851. | 1852. | 1851. | 1852. | 1851. | 1852. | 1851. | 1852. |
| BRITISH PLANTATION. | | | | | | | | |
| West India | 190,800 | 143,300 | 98,800 | 136,400 | — | — | 41,800 | 40,100 |
| Mauritius | 45,400 | 49,000 | 38,400 | 47,100 | — | — | 14,700 | 14,700 |
| East India | 54,600 | 49,500 | 50,900 | 61,900 | — | — | 28,800 | 24,300 |
| Total B. P. | 290,800 | 241,800 | 187,500 | 245,300 | — | — | 84,500 | 79,100 |
| FOREIGN. | | | | | | | | |
| Manilla, &c. | 12,700 | 5,800 | 3,200 | 1,000 | 5,500 | 4,100 | 11,200 | 8,500 |
| Brazil | 24,500 | 11,400 | 11,600 | 1,900 | 7,000 | 8,600 | 25,100 | 16,600 |
| Cuba | 28,800 | 20,400 | 25,100 | 18,200 | 4,800 | 9,400 | 27,500 | 20,700 |
| Porto Rico, &c. | 17,300 | 6,600 | 15,700 | 7,000 | 1,400 | 3,100 | 6,800 | 3,500 |
| Total Foreign | 103,300 | 44,900 | 55,700 | 25,100 | 18,800 | 25,200 | 70,500 | 49,300 |
| Total B. P. | 220,800 | 241,900 | 187,500 | 245,300 | — | — | 84,500 | 79,100 |
| Total SUGAR | 324,100 | 286,000 | 243,200 | 270,400 | 18,800 | 25,200 | 155,100 | 128,400 |
| MOLASSES (reduced to Sugar) | 18,200 | 11,800 | 15,500 | 14,600 | — | — | 11,800 | 6,000 |
| Total | 240,400 | 297,300 | 258,700 | 285,000 | 18,800 | 25,200 | 166,900 | 124,400 |

SUGAR in EUROPE, including GREAT BRITAIN, for the Ten Months ending 31st October, 1850, 1851, and 1852.

| | IMPORT. | | | STOCK. | | |
|------------------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | 1850. | 1851. | 1852. | 1850. | 1851. | 1852. |
| | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. |
| Holland | 95,600 | 97,660 | 86,100 | 2,400 | 13,710 | 6,400 |
| Antwerp | 30,730 | 13,650 | 19,540 | 2,060 | 3,870 | 2,060 |
| Hamburgh | 25,250 | 23,500 | 20,250 | 5,750 | 8,750 | 4,250 |
| Bremen | 5,500 | 7,750 | 4,460 | 300 | 1,200 | 300 |
| Havre | 22,650 | 20,360 | 37,120 | 4,770 | 2,830 | 10,670 |
| Trieste | 43,870 | 26,490 | 39,270 | 18,810 | 10,210 | 10,410 |
| Genoa | 17,220 | 8,290 | 14,630 | 4,690 | 3,300 | 2,780 |
| Leghorn | 7,050 | 8,540 | 7,330 | 1,560 | 810 | 850 |
| TOTAL CONTINENT | 249,870 | 201,280 | 228,700 | 46,140 | 44,890 | 37,740 |
| Great Britain | 290,790 | 240,400 | 267,300 | 118,540 | 166,900 | 124,400 |
| TOTAL EUROPE | 540,660 | 441,680 | 496,000 | 164,680 | 211,790 | 172,140 |

Sugar in United Kingdom, (refined, or equal to refined).

| Years. | Import. | Consumption. | Export. |
|--------|---------|--------------|---------|
| | Tons. | Tons. | Tons. |
| 1847 | 4,820 | 1,260 | 2,930 |
| 1848 | 11,040 | 2,220 | 5,130 |
| 1849 | 15,220 | 3,070 | 9,900 |
| 1850 | 17,890 | 5,840 | 4,520 |
| 1851 | 21,930 | 16,930 | 2,650 |

MOLASSES.

| Years. | Import. | Consumption. | Export. |
|--------|---------|--------------|---|
| | Tons. | Tons. | |
| 1847 | 47,490 | 31,930 | The exports of molasses are very insignificant. |
| 1848 | 25,890 | 31,850 | |
| 1849 | 53,130 | 40,620 | |
| 1850 | 45,250 | 45,860 | |
| 1851 | 39,550 | 38,650 | |

* For these important tables, I am indebted to James Cook, Esq., of Mincing Lane.

Production, Consumption, and Stocks of Sugar, from March, 1843 (in Thousands of Tons).

| | 1843. | | 1844. | | 1845. | | 1846. | | 1847. | | 1848. | | 1849. | | 1850. | | 1851. | | 1852.* | | 1853.* | | |
|---|-------|-----|-------|-----|-------|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|-------|--------|-------|--|
| | | | | | | | | | | | | | | | | | | | | | | | |
| <i>In Thousands of Tons.</i> | | | | | | | | | | | | | | | | | | | | | | | |
| Stock in Europe, March 31 | - | 97 | - | 80 | - | 122 | - | 121 | - | 87 | - | 143 | - | 123 | - | 160 | - | 145 | - | 185 | - | 143 | |
| <i>Production.</i> | | | | | | | | | | | | | | | | | | | | | | | |
| British West Indies | - | 125 | - | 126 | - | 142 | - | 109 | - | 129 | - | 140 | - | 148 | - | 129 | - | 153 | - | 170 | - | 170 | |
| Mauritius | - | 23 | - | 25 | - | 26 | - | 43 | - | 64 | - | 89 | - | 81 | - | 86 | - | 87 | - | 86 | - | 86 | |
| Bengal and Madras | - | 54 | - | 57 | - | 67 | - | 68 | - | 70 | - | 67 | - | 73 | - | 67 | - | 78 | - | 65 | - | 70 | |
| French Colonies | - | 80 | - | 87 | - | 102 | - | 80 | - | 88 | - | 48 | - | 63 | - | 51 | - | 60 | - | 65 | - | 65 | |
| Dutch and Danish West Indies | - | 25 | - | 23 | - | 25 | - | 20 | - | 25 | - | 20 | - | 20 | - | 20 | - | 20 | - | 16 | - | 20 | |
| Cuba and Porto Rico | - | 185 | - | 220 | - | 115 | - | 220 | - | 310 | - | 290 | - | 260 | - | 314 | - | 375 | - | 335* | - | 330 | |
| Java | - | 53 | - | 63 | - | 66 | - | 66 | - | 81 | - | 97 | - | 100 | - | 97 | - | 104 | - | 120 | - | 120 | |
| Sum and Manilla | - | 13 | - | 13 | - | 15 | - | 25 | - | 20 | - | 20 | - | 25 | - | 20 | - | 20 | - | 40 | - | 40 | |
| Brazil | - | 63 | - | 69 | - | 98 | - | 75 | - | 112 | - | 120 | - | 104 | - | 102 | - | 117 | - | 91 | - | 120 | |
| Louisiana and Texas | - | 70 | - | 25 | - | 95 | - | 90 | - | 65 | - | 120 | - | 123 | - | 104 | - | 125 | - | 180 | - | 180 | |
| Beet-root | - | 55 | - | 60 | - | 70 | - | 80 | - | 90 | - | 97 | - | 124 | - | 175 | - | 162 | - | 150* | - | 180 | |
| Total | - | 751 | - | 807 | - | 849 | - | 907 | - | 1,094 | - | 1,078 | - | 1,096 | - | 1,147 | - | 1,281 | - | 1,266 | - | 1,331 | |
| Total supplies | - | 848 | - | 837 | - | 971 | - | 1,028 | - | 1,181 | - | 1,221 | - | 1,219 | - | 1,207 | - | 1,286 | - | 1,443 | - | 1,474 | |
| Deduct stock 31st March | - | 80 | - | 122 | - | 121 | - | 87 | - | 143 | - | 122 | - | 160 | - | 145 | - | 186 | - | 143 | - | 143 | |
| Total consumption years ending 31st March | - | 768 | - | 765 | - | 850 | - | 941 | - | 1,038 | - | 1,098 | - | 1,069 | - | 1,163 | - | 1,241 | - | 1,200 | - | 1,200 | |

* Approximations have been given for the years 1852, 1853.

Official Statement of SUGAR and MOLASSES in the United Kingdom, for the Nine Months, ending 10th October 1852, compared with 1850 and 1851.

| | IMPORT. | | | | CONSUMPTION. | | | | EXPORT. | | | |
|---|---------|---------|---------|---------|------------------|--------------|--------|--------|---------|-------|-------|-------|
| | 1850. | 1851. | 1852. | 1850. | 1851. | 1852. | 1850. | 1851. | 1852. | 1850. | 1851. | 1852. |
| | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. |
| SUGAR. | | | | | | | | | | | | |
| RAW. | | | | | | | | | | | | |
| Of British Possessions - | 204,180 | 208,010 | 240,560 | 211,850 | 184,790 | 241,520 | 17,320 | 9,460 | 17,150 | — | — | — |
| Foreign - | 51,810 | 94,970 | 43,870 | 30,150 | 55,860 | 26,440 | 17,320 | 9,460 | 17,150 | — | — | — |
| TOTAL RAW | 255,990 | 302,980 | 284,430 | 242,000 | 240,650 | 267,960 | 17,320 | 9,460 | 17,150 | — | — | — |
| | | | | | Refined, in bond | | | | | | | |
| REFINED. | | | | | | TOTAL | | | | | | |
| Of British Possessions - | 190 | 1,400 | 150 | 540 | 1,550 | 220 | 10 | 10 | — | — | — | — |
| Foreign - | 10,950 | 17,040 | 11,910 | 9,080 | 12,620 | 11,100 | 4,250 | 2,350 | 1,920 | — | — | — |
| TOTAL REFINED | 11,140 | 18,440 | 12,060 | 9,620 | 14,170 | 11,320 | 4,260 | 2,360 | 1,920 | — | — | — |
| Total of all kinds for the 9 Months, ending 10th October - | 267,190 | 321,420 | 296,460 | 245,620 | 254,820 | 279,280 | 29,570 | 21,900 | 27,430 | — | — | — |
| Last Three Months of 1850 and 1851 - | 65,380 | 98,020 | — | 65,870 | 74,880 | — | 3,920 | 9,020 | — | — | — | — |
| Total of Sugar of all kinds for the years 1850 and 1851 - | 332,460 | 419,440 | — | 311,490 | 329,700 | — | 33,470 | 30,920 | — | — | — | — |
| MOLASSES, Nine Months - | 41,090 | 31,170 | 22,060 | 35,150 | 29,640 | 29,560 | 220 | 350 | 210 | — | — | — |
| Last Three Months of 1850 and 1851 - | 4,120 | 6,380 | — | 10,790 | 9,010 | — | 40 | 310 | — | — | — | — |
| Total for the Years 1850 and 1851 - | 45,150 | 39,550 | — | 45,880 | 38,650 | — | 260 | 660 | — | — | — | — |

Sugar in United Kingdom, (unrefined, or not equal to refined).

| Years. | Imports. | Consumption. | Exports Raw. | Refined in Bond. |
|--------|----------|--------------|--------------|------------------|
| | Tons. | Tons. | Tons. | Tons. |
| 1840 | 201,790 | 179,740 | 11,480 | 11,760 |
| 1841 | 245,250 | 202,880 | 21,270 | 15,610 |
| 1842 | 237,800 | 193,420 | 20,090 | 13,740 |
| 1843 | 251,030 | 201,410 | 28,680 | 13,000 |
| 1844 | 244,000 | 206,470 | 16,690 | 10,960 |
| 1845 | 291,040 | 242,830 | 30,800 | 13,690 |
| 1846 | 281,130 | 261,010 | 12,040 | 11,340 |
| 1847 | 410,480 | 288,980 | 40,200 | 11,460 |
| 1848 | 343,500 | 307,120 | 16,630 | 12,440 |
| 1849 | 346,290 | 296,110 | 27,930 | 11,150 |
| 1850 | 314,570 | 304,570 | 18,490 | 10,460 |
| 1851 | 397,010 | 312,770 | 15,340 | 12,930 |

| Months 1852. | England. | Hamburg. | France. | United States. | Holland. | West Indies. | Chill. | Callao. | Total. |
|--------------|----------|----------|---------|----------------|----------|--------------|--------|---------|---------|
| | Qls. | Qls. | Qls. | Qls. | Qls. | Qls. | Qls. | Qls. | Qls. |
| January | 37,441 | - - - | - - - | 6,126 | 7,499 | - - - | 1,100 | - - - | 51,866 |
| February | - - - | - - - | 4,211 | 17,633 | 5,473 | 2,287 | - - - | - - - | 29,594 |
| March | 19,527 | 4,002 | 11,000 | 11,180 | - - - | - - - | - - - | - - - | 45,709 |
| April | 22,055 | 7,040 | - - - | - - - | - - - | - - - | - - - | - - - | 29,095 |
| May | 46,493 | 25,130 | 12,572 | - - - | - - - | - - - | - - - | - - - | 84,193 |
| June | 5,500 | 2,000 | - - - | - - - | 6,500 | - - - | - - - | - - - | 14,000 |
| July | 42,169 | 4,628 | 6,029 | - - - | - - - | - - - | - - - | - - - | 62,826 |
| August | 64,096 | - - - | 7,000 | - - - | - - - | - - - | - - - | 839 | 71,935 |
| September. | 14,777 | - - - | 5,600 | - - - | - - - | - - - | - - - | 900 | 21,277 |
| | 251,758 | 52,800 | 46,410 | 34,949 | 19,472 | 2,287 | 1,100 | 1,737 | 410,495 |

SUGAR OF LEAD, properly *Acetate of lead*, (*Acetate de plomb*; *Sel de Saturne*, Fr.; *Essigsäures Bleioxyd*, *Bleizucker*, Germ.) is prepared by dissolving pure litharge, with heat, in strong vinegar, made of malt, wood, or wine, till the acid be saturated. A copper boiler, rendered negatively electrical by soldering a strap of lead within it, is the best adapted to this process on the great scale. 325 parts of finely ground and sifted oxide of lead require 575 parts of strong acetic acid, of spec. grav. 7° Baumé, for neutralization, and afford 960 parts of crystallized sugar of lead. The oxide should be gradually sprinkled into the moderately hot vinegar, with constant stirring, to prevent adhesion to the bottom; and when the proper quantity is dissolved, the solution may be weakened with some of the washings of a preceding process, to dilute the acetate, after which the whole should be heated to the boiling point, and allowed to cool slowly in order to settle. The limpid solution is to be drawn off by a syphon, concentrated by boiling to the density of 32° B., taking care that there be always a faint excess of acid, to prevent the possibility of any basic salt being formed, which would interfere with the formation of regular crystals. Should the concentrated liquor be coloured, it may be whitened by filtration through granular bone black.

Stoneware vessels, with salt glaze, answer best for crystallizers. Their edges should be smeared with candle-grease, to prevent the salt creeping over them by *efflorescent vegetation*. The crystals are to be drained, and dried in a stove-room very slightly heated. It deserves remark, that linen, mats, wood, and paper, imbued with sugar of lead, and strongly dried, readily take fire, and burn away like tinder. When the mother waters cease to afford good crystals, they should be decomposed by carbonate of soda, or by lime skilfully applied, when a carbonate or an oxide will be obtained, fit for treating with fresh vinegar. The supernatant acetate of soda may be employed for the extraction of pure acetic acid.

A main point in the preparation of sugar of lead, is to use a strong acid; otherwise much time and acid are wasted in concentrating the solution. This salt crystallizes in colourless, transparent, four and six sided prisms, from a moderately concentrated solution; but from a stronger solution, in small needles, which have a yellow cast if the acid has been slightly impure. It has no smell, a sweetish astringent metallic taste, &

specific gravity of 2.945; it is permanent in the air at ordinary temperatures, but effloresces when heated to 95°, with the loss of its water of crystallization and some acid, falling into a powder, which passes in the air slowly into carbonate of lead. The crystals dissolve in 1½ times their weight of water at 60°, but in much less of boiling water, and in 8 parts of alcohol. The solution feebly reddens litmus paper, but has an alkaline reaction upon the colours of violets and turmeric. The constituents of the salt are, 58.71 oxide of lead, 27.08 acetic acid, and 14.21 water, in 100.

Acetate of lead is much used in calico-printing. It is poisonous, and ought to be prepared and handled with attention to this circumstance.

There are two subacetates of lead; the first of which, the ter-subacetate, has three atoms of base to one of acid, and is the substance long known by the name of Goulard's extract. It may be obtained by digesting with heat a solution of the neutral acetate, upon pure litharge or massicot. The solution affords white crystalline scales, which do not taste so sweet as sugar of lead, dissolve in not less than 30 parts of water, are insoluble in alcohol, and have a decided alkaline reaction upon test paper. Carbonic acid, transmitted through the solution, precipitates the excess of the oxide of lead, in the state of a carbonate, a process long ago prescribed by Thenard for making white-lead. This sub-acetate consists of 86.66 of oxide, and 13.34 acid, in 100 parts. It is employed for making the orange sub-chromate of lead, as also sometimes in surgery.

A *sex-subacetate*, containing six atoms of base, may be obtained by adding ammonia in excess to a solution of the preceding salt, and washing the precipitate with dilute water of ammonia. A white powder is thus formed, that dissolves sparingly in cold water, but gives a solution in boiling water, from which white silky needles are deposited. It consists of 92.86 oxide, and 7.14 acid.

SULPHATES, are saline compounds of sulphuric acid with oxidised bases. The minutest quantity of them present in any solution, may be detected by the precipitate, insoluble in nitric or muriatic acid, which they afford with nitrate or muriate of baryta. They are mostly insoluble in alcohol.

SULPHATE OF ALUMINA AND POTASSA, is alum.

SULPHATE OF AMMONIA, is a salt sometimes formed by saturating the ammonia liquor of the gas-works with sulphuric acid; and it is employed for making carbonate of ammonia. See AMMONIA and SAL AMMONIAC.

This salt, now so extensively used in preparing artificial manures and imitations of guano, for farmers, is made of great purity, and at an economical rate, by the patent process of Mr. Evans, described under the article GAS. A mixture of 10 per cent. of this sulphate with 20 of bone-dust, some gypsum and farmyard manure, will form a very fertilising compost, applicable to a great variety of soils.

SULPHATE OF BARYTA, is the mineral called heavy-spar, which frequently forms the gangue or vein-stone of lead and other metallic ores.

SULPHATE OF COPPER, *Roman or Blue Vitriol* (*Vitriol de Chypre*, Fr.; *Kupfervitriol*, Germ.); is a salt composed of sulphuric acid and oxide of copper, and may be formed by boiling the concentrated acid upon the metal, in an iron pot. It is, however, a natural product of many copper mines, from which it flows out in the form of a blue water, being the result of the infiltration of water over copper pyrites, which has become oxygenated by long exposure to the air in subterranean excavations. The liquid is concentrated by heat in copper vessels, then set aside to crystallize. The salt forms in oblique four-sided tables, of a fine blue colour; has a spec. gravity of 2.104; an acerb, disagreeable, metallic taste; and, when swallowed, it causes violent vomiting. It becomes of a pale dirty blue, and effloresces slightly, on long exposure to the air; when moderately heated, it loses 36 per cent. of water, and falls into a white powder. It dissolves in 4 parts of water, at 60°, and in 2 of boiling water, but not in alcohol; the solution has an acid reaction upon litmus paper. When strongly ignited, the acid flies off, and the black oxide of copper remains. The constituents of crystallized sulphate of copper are—oxide, 31.80; acid 32.14; and water, 36.06. Its chief employment in this country is in dyeing, and for preparing certain green pigments. See SCHEEL'S and SCHWEINFURTH GREEN. In France, the farmers sprinkle a weak solution of it upon their grains and seeds before sowing them, to prevent their being attacked by birds and insects.

SULPHATE OF IRON, *Green vitriol*, *Copperas* (*Couperose verte*, Fr.; *Eisen-vitriol*, *Schwefelsaures Eisenoxydul*, Germ.); is a crystalline compound of sulphuric acid and protoxide of iron; hence called, by chemists, the protosulphate; consisting of, 26.10 of base, 29.90 of acid, and 44.00 of water, in 100 parts; or of 1 prime equivalent of protoxide, 36, + 1 of acid, 40, + 7 of water, 63, = 139. It may be prepared by dissolving iron to saturation in dilute sulphuric acid, evaporating the solution till a pellicle forms upon its surface, and setting it aside to crystallize. The copperas of commerce is made in a much cheaper way, by stratifying the pyrites found in the coal

measures (*Vitriolies* and *Strahlies* of the Germans), upon a sloping puddled platform of stone, leaving the sulphuret exposed to the weather, till, by the absorption of oxygen, it effloresces, lixiviating with water the supersulphate of iron thus formed, saturating the excess of acid with plates of old iron, then evaporating and crystallizing. The other pyrites, which occurs often crystallized, called by the Germans *Schweifelkies* or *Eisarkies*, must be deprived of a part of its sulphur by calcination, before it acquires the property of absorbing oxygen from the atmosphere, and thereby passing from a bisulphuret into a bisulphate. Alum schist very commonly contains vitriolies, and affords, after being roasted and weather-worn, a considerable quantity of copperas, which must be carefully separated by crystallization from the alum.

This liquor used formerly to be concentrated directly in leaden vessels; but the first stage of the operation is now carried on in stone canals of considerable length, vaulted over with bricks, into which the liquor is admitted, and subjected at the surface to the action of flame and heated air, from a furnace of the reverberatory kind, constructed at one end, and discharging its smoke by a high chimney raised at the other. See *SODA MANUFACTURE*. Into this oblong trough, resting on dense clay, and rendered tight in the joints by water-cement, old iron is mixed with the liquor, to neutralize the excess of acid generated from the pyrites, as also to correct the tendency to superoxidizement in copperas, which would injure the fine green colour of the crystals. After due concentration and saturation in this surface evaporator, the solution is run off into leaden boilers, where it is brought to the proper density for affording regular crystals, which it does by slow cooling, in stone cisterns.

Copperas forms sea-green, transparent, rhomboidal prisms, which are without smell, but have an astringent, acerb, inky taste; they speedily become yellowish-brown in the air, by peroxidizement of the iron, and effloresce in a warm atmosphere: they dissolve in 1.43 parts of water at 60°, in 0.27 at 190°, and in their own water of crystallization at a higher heat. This salt is extensively used in dyeing black, especially hats, in making ink and prussian blue, for reducing indigo in the blue vat, in the China blue dye, for making the German oil of vitriol, and in many chemical and medicinal preparations.

There is a persulphate and subsulphate of iron, but they belong to the domain of chemistry. The first may be formed, either by dissolving with heat one part of red oxide of iron (colcothar) in one-and-a-half of concentrated sulphuric acid, or by adding some nitric acid to a boiling-hot solution of copperas. It forms with galls and logwood a very black ink, which is apt to become brown-black. When evaporated to dryness, it appears as a dirty white pulverulent substance, which is soluble in alcohol. It consists, in 100 parts, of 39.42 of red oxide of iron, and 60.58 sulphuric acid.

Hydrated peroxide of iron, prepared by precipitation with alkali from solution of the persulphate, is an excellent antidote against poisoning by arsenic. A French *peruquier*, who had swallowed two drams of arsenious acid, was, after an interval of twenty minutes, treated with the oxide precipitated from 6 ounces of that salt by caustic potash. It was diffused in 20 quarts of weak syrup, and administered in successive doses. After repeated vomiting and purging, the patient felt no more pain, and was pronounced by the physician to be quite convalescent.

In the copperas and alum works, a very large quantity of ochrey sediment is obtained; which is a peroxide of iron, containing a little sulphuric acid and alumina. This deposit, calcined in reverberatory hearths, becomes of a bright-red colour; and when ground and elutriated, in the same way as is described under *white lead*, forms a cheap pigment, in very considerable demand, called *English red*, in the French market.

Colcothar of Vitriol, and Crocus of Mars, are old names for red oxide of iron. This brown-red powder is obtained in its purest state, by calcining dried sulphate of iron in a furnace till all its acid be expelled, and its base become peroxidized. It must be levigated, elutriated, and dried. This powder is employed extensively in the steel manufacture, for giving the finishing lustre to fine articles; it is used by silversmiths under the name of plate powder and *rouge*; and by the opticians for polishing the specula of reflecting telescopes. Much of the *crocus* in the market, is made, however, from the copperas and alum sediments, and is greatly inferior to the article prepared by the last process. The finest *rouge* is made by precipitating the oxide with soda, then washing and calcining the powder.

An excellent powder for applying to razor-strops, is made by igniting together in a crucible equal parts of well-dried copperas and sea salt. The heat must be slowly raised and well regulated, otherwise the materials will boil over in a pasty state, and the product will be in a great measure lost. When well made, out of contact of air, it has the brilliant aspect of plumbago. It has a satiny feel, and is a true *fer oleagineus*, similar in composition to the Elba iron ore. It requires to be ground and elutriated; after which it affords, on drying, an impalpable powder, that may be either rubbed on a strop of smooth buff leather, or mixed up with hog's-lard or tallow into a stiff cerate.

SULPHATE OF LIME. See *Gypsum*.

SULPHATE OF MAGNESIA, *Epsom Salt* (*Sel amer*, Fr.; *Bittersalz*, Germ.); exists in sea-water, as also in the waters of Saidschütz, Sedlitz, and Püllna; and in many saline springs, besides Epsom in Surrey, whence it has derived its trivial name, and from which it was first extracted, in the year 1695, and continued to be so, till modern chemistry pointed out cheaper and more abundant sources of this useful purgative salt. The sulphate of magnesia, occasionally found effloresced on the surface of minerals in crystalline filaments, was called *haarsalz* (hair salt) by the older writers. The bittern of the Scotch sea-salt works is muriate of magnesia, mixed with a little sulphate of magnesia and chloride of sodium. If the proper decomposing quantity (found by trial) of sulphate of soda be added to it, and the mixed solution be evaporated at the temperature of 122° F., chloride of sodium will form by double affinity, and fall down in cubical crystals; while the solution of sulphate of magnesia which remains, being evaporated to the proper point, will afford regular crystals in four-sided prisms with four-sided acuminations. Or, if bittern be treated in a retort with the equivalent quantity of sulphuric acid, the muriatic acid may be distilled off into a series of Woulfe's bottles, and the sulphate of magnesia, soda, and lime, will remain in the retort, from which mixture the sulphate of magnesia may be separated by filtration and crystallization.

Magnesian limestone being digested with as much muriatic acid as will dissolve out its lime only, will, after washing, afford, with the equivalent quantity of sulphuric acid, a pure sulphate of magnesia; and this is certainly the simplest and most profitable process for manufacturing this salt upon the great scale. Many prepare it directly, by digesting upon magnesian limestone the equivalent saturating quantity of dilute sulphuric acid. The sulphate of lime being separated by subsidence, the supernatant solution of sulphate of magnesia is evaporated and crystallized.

This salt is composed of, magnesia 16·72, sulphuric acid 32·39, and water 50·89. When free from muriate, it tends to effloresce in the air. It dissolves in 4 parts of water at 32°, in 3 parts at 60°, in 1·4 at 200°, and in its own water of crystallization at a higher heat.

SULPHATE OF MANGANESE, is prepared on the great scale for the calico-printers, by exposing the peroxide of the metal and pitcoal ground together, and made into a paste with sulphuric acid, to a heat of 400° F. On lixiviating the calcined mass, a solution of the salt is obtained, which is to be evaporated and crystallized. It forms pale amethyst-coloured prisms, which have an astringent bitter taste, dissolve in 2½ parts of water, and consist of, protoxide of manganese 31·93, sulphuric acid 35·87, and water 32·20, in 100 parts.

SULPHATE OF MERCURY, is a white salt which is used in making corrosive sublimate. See *MERCURY*. The subsulphate, called *Turbith Mineral*, is a pale yellow pigment, and may be prepared by washing the white sulphated peroxide with hot water, which resolves it into the soluble supersulphate, and the insoluble subsulphate, or *Turbith*. It is poisonous.

SULPHATE OF POTASSA, is obtained by first igniting and then crystallizing the residuum of the distillation of nitric acid from nitre.

SULPHATE OF SODA, is commonly called Glauber's salt, from the name of the chemist who first prepared it. It is obtained by igniting and then crystallizing the residuum of the distillation of muriatic acid from common salt. It crystallizes in channelled 6-sided prisms. See *SODA MANUFACTURE*.

SULPHATE OF ZINC, called also *White Vitriol*, is commonly prepared in the Harz, by washing the calcined and effloresced sulphuret of zinc or blende, on the same principle as green and blue vitriol are obtained from the sulphurets of iron and copper. Pure sulphate of zinc may be made most readily by dissolving the metal in dilute sulphuric acid, evaporating and crystallizing the solution. It forms prismatic crystals, which have an astringent, disagreeable, metallic taste; they effloresce in a dry air, dissolve in 2·3 parts of water at 60°, and consist of—oxide of zinc, 28·29; acid, 28·18; water, 43·53. Sulphate of zinc is used for preparing drying oils for varnishes, and in the reserve or resist pastes of the calico-printer.

SULPHITES, are a class of salts, consisting of sulphurous acid, combined in equivalent proportions with the oxidized bases.

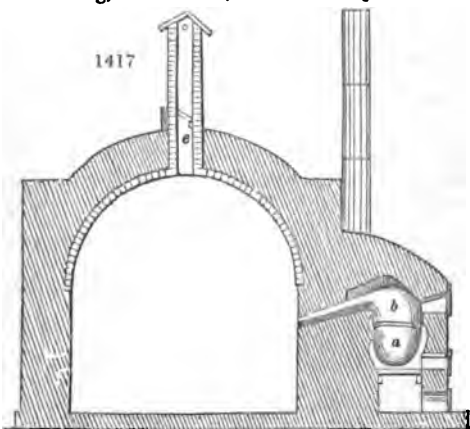
SULPHOSELS, is the name given by Berzelius to a class of salts which may be prepared as follows:—1. Dissolve a salt consisting of an oxide and an acid (an *oxisalt*), in a very small quantity of water, and pass through the solution a stream of sulphuretted hydrogen, till the salt be entirely decomposed. In this operation, the *oxisalt* is transformed into a *sulphosalt*, by the sulphur of the compound gas; while its hydrogen forms water with the oxygen of the saline base. This process is applicable only to the metallic salts; and among these, not to the nitrates, carbonates, or phosphates. 2. Another method of preparing *sulphosalts* is, to add to a watery solution of sulphuret of

potassium, an electro-negative metallic sulphuret, which will dissolve in the liquid till the sulphuret of potassium be saturated. This saline compound is to be employed to effect double decompositions with the oxisalts; that is, to convert the radical of another base, combined with an *oxacid*, into a sulphosalt. 3. If the electro-negative sulphuret be put in powder into a solution of the hydrosulphuret of potassa, it will dissolve and expel the sulphuretted hydrogen with effervescence; just as carbonic acid is displaced by a stronger acid. For his other three methods of preparing *sulphosalts*, see his *Elements*, vol. iii. p. 336, Fr. translation.

SULPHUR; *Brimstone* (*Soufre*, Fr.; *Schwefel*, Germ.); is a simple combustible, solid, non-metallic, of a peculiar yellow colour, very brittle, melting at the temperature of 226° Fahr., and possessing, after it has been fused, a specific gravity of 1.99. When held in a warm hand, a roll of sulphur emits a crackling sound, by the fracture of its interior parts; and when it is rubbed, it emits a peculiar well-known smell, and acquires at the same time negative electricity. When heated to the temperature of 560° F. it takes fire, burns away with a dull blue flame of a suffocating odour, and leaves no residuum. When more strongly heated, sulphur burns with a vivid white flame. It is not affected by air or water.

Sulphur is an abundant product of nature; existing sometimes pure or merely mixed, and at others in intimate chemical combination with oxygen, and various metals, forming sulphates and sulphurets. See Ores of COPPER, IRON, LEAD, &c., under these metals.

Fig. 1417. represents one of the cast-iron retorts used at Marseilles for refining sulphur, wherein it is melted and converted into vapours, which are led into a large chamber for condensation. The body *a*, of the retort is an iron pot, 3 feet in diameter outside, 22 inches deep, half an inch thick, which weighs 14 cwt., and receives a charge of 8 cwt. of crude sulphur. The grate is 8 inches under its bottom, whence the flame rises and plays round its sides. A cast-iron capital *b*, being luted to the pot, and covered with sand, the opening in front is shut with an iron plate. The chamber *d*, is 23 feet long, 11 feet wide, and 13 feet high, with walls 32 inches thick. In the roof,



at each gable, valves or flap-doors, *e*, 10 inches square, are placed at the bottom of the chimney *c*. The cords for opening the valves are led down to the side of the furnace. The entrance to the chamber is shut with an iron door. In the wall opposite to the retorts, there are two apertures near the floor, for taking out the sulphur. Each of the two retorts belonging to a chamber is charged with 7½ or 8 cwt. of sulphur; but one is fired first, and with a gentle heat, lest the brimstone froth should overflow; but when the fumes begin to rise copiously, with a stronger flame. The distillation commences within an hour of kindling the fire, and is

completed in six hours. Three hours after putting fire to the first retort, the second is in like manner set in operation.

When the process of distillation is resumed, after having been some time suspended, explosions may be apprehended, from the presence of atmospheric air; to obviate the danger of which, the flap-doors must be opened every 10 minutes; but they should remain closed during the setting of the retorts, and the reflux of sulphurous fumes or acid should be carried off by a draught-hood over the retorts. The distillation is carried on without interruption during the week, the charges being repeated four times in the day. By the third day, the chamber acquires such a degree of heat as to preserve the sulphur in a liquid state; on the sixth, its temperature becoming nearly 300° F., gives the sulphur a dark hue, on which account the furnace is allowed to cool on the Sunday. The fittest distilling temperature is about 248°. The sulphur is drawn off through two iron pipes cast in the iron doors of the orifices on the side of the chamber opposite to the furnace. The iron stoppers being taken out of the mouths of the pipes, the sulphur is allowed to run along an iron spout placed over red-hot charcoal, into the appropriate wooden moulds.

Native sulphur in its pure state is solid, brittle, transparent, yellow, or yellow border-

ing on green, and of a glassy lustre when newly broken. It occurs frequently in crystalline masses, and sometimes in complete and regular crystals, which are all derivable from the rhomboidal octahedron. The fracture is usually conchoidal and shining. Its specific gravity is 2.072, exceeding somewhat the density of melted sulphur. It possesses a very considerable refractive power; and doubles the images of objects even across two parallel faces. Sulphur, crystallized by artificial means, presents a very remarkable phenomenon; for by varying the processes, crystals are obtained whose forms belong to two different systems of crystallization. The red tint, so common in the crystals of Sicily, and of volcanic districts, has been ascribed by some mineralogists to the presence of realgar, and by others to iron; but Stromeyer has found the sublimed orange-red sulphur of Vulcano, one of the Lipari islands, to result from a natural combination of sulphur and selenium.

It is extracted from the minerals containing it, at Solfatara, by the following process:—

Ten earthen pots, of about a yard in height, and 4½ gallons imperial in capacity, bulging in the middle, are ranged in a furnace called a gallery; five being set on the one side, and five on the other. These are so distributed in the body of the walls of the gallery, that their belly projects partly without, and partly within, while their top rises out of the vault of the roof. The pots are filled with lumps of the sulphur ore of the size of the fist; their tops are closed with earthenware lids, and from their shoulder proceeds a pipe of about 2 inches diameter, which bends down, and enters into another covered pot, with a hole in its bottom, standing over a tub filled with water. On applying heat to the gallery, the sulphur melts, volatilizes, and runs down in a liquid state into the tubs, where it coagals. When one operation is finished, the pots are re-charged, and the process is repeated.

In Saxony and Bohemia, the sulphurets of iron and copper are introduced into large earthenware pipes, which traverse a furnace-gallery; and the sulphur exhaled flows into pipes filled with cold water, on the outside of the furnace. 900 parts of sulphuret afford from 100 to 150 of sulphur, and a residuum of metallic protosulphuret. See **METALLURGY AND COPPER.**

Volcanic sulphur is purer than that extracted from pyrites; and as the latter is commonly mixed with arsenic, and some other metallic impregnations, sulphuric acid made of it would not answer for many purposes of the arts; though a tolerably good sulphuric acid may be made directly from the combustion of pyrites, instead of sulphur, in the lead chambers. The present high price of the Sicilian sulphur is a great encouragement to its extraction from pyrites. It is said that the common English brimstone, such as was extracted from the copper pyrites of the Parys mine of Anglesey, contained fully a fifteenth of residuum, insoluble in boiling oil of turpentine, which was chiefly orpiment; while the fine Sicilian sulphur, now imported in vast quantities by the manufacturers of oil of vitriol, contains not more than 3 per cent. of foreign matter, chiefly earthy, but not at all arsenical.

Sulphur has been known from the most remote antiquity. From its kindling at a moderate temperature, it is employed for readily procuring fire, and lighting by its flame other bodies not so combustible. At Paris, the preparation of sulphur matches constitutes a considerable branch of industry. The sulphurous acid formed by the combustion of sulphur in the atmospheric air, is employed to bleach woollen and silken goods, as also cotton stockings; to disinfect vitiated air, though it is inferior in power to nitric acid vapour and chlorine; and to kill mites, moths, and other destructive insects in collections of zoology; and to counteract too rapid fermentation in wine-vats, &c. As the same acid gas has the property of suddenly extinguishing flame, sulphur has been thrown into a chimney on fire, with the best effect; a handful of it being sometimes sufficient. Sulphur is also employed for cementing iron bars in stone; for taking impressions from seals and cameos, for which purpose it is kept previously melted for some time, to give the casts an appearance of bronze. Its principal uses, however, are for the manufactures of vermilion, or cinnabar, gunpowder, and sulphuric acid.

See **METALLURGY**, page 157, for the description of Gahn's furnace for extracting sulphur from pyrites.

Pyrites as a bi-sulphuret, consisting of 45.5 parts of iron, and 54.5 of sulphur, may, by proper chemical means, be made to give off one half of its sulphur, or about 27 per cent.; but great care must be taken not to generate sulphurous acid, as is done very wastefully by the Fahlun and the Goslar processes. By the latter, indeed, not more than 1 or 2 parts of sulphur are obtained, by roasting 100 parts of the pyritous ores of the Rammelsberg mines. In these cases, the sulphur is burned, instead of being sublimed. The residuum of the operation, when it is well conducted, is black sulphuret of iron, which may be profitably employed for making copperas. The apparatus for extracting sulphur from pyrites should admit no more air than is barely necessary to promote the sublimation.—Sicily produced last year 70,000 tons of sulphur, and Tus-

cany 1200; of which Great Britain consumed 46,000; France, 18,000; other places, 6000. In 1820, Great Britain consumed only 5000 tons.

SULPHURATION, is the process by which woollen, silk, and cotton goods are exposed to the vapours of burning sulphur, or to sulphurous acid gas. In the article STRAW-HAT MANUFACTURE, I have described a simple and cheap apparatus, well adapted to this operation.

Sulphuring-rooms are sometimes constructed upon a great scale, in which blankets, shawls, and woollen clothes may be suspended freely upon poles or cords. The floor should be flagged with a sloping pavement, to favour the drainage of the water that drops down from the moistened cloth. The iron or stoneware vessels, in which the sulphur is burned, are set in the corners of the apartment. They should be increased in number according to the dimensions of the place, and distributed uniformly over it. The windows and the entrance door must be made to shut hermetically close. In the lower part of the door, there should be a small opening, with a sliding shutter, which may be raised or lowered by the mechanism of a cord passing over a pulley.

The aperture by which the sulphurous acid and azotic gases are let off, in order to carry on the combustion, should be somewhat larger than the opening at the bottom. A lofty chimney carries the noxious gases above the building, and diffuses them over a wide space, their ascension being promoted by means of a draught-pipe of iron, connected with an ordinary stove, provided with a valve to close its orifice when not kindled.

When the chamber is to be used, the goods are hung up, and a small fire is made in the draught-stove. The proper quantity of sulphur being next put into the shallow pans, it is kindled, the entrance door is closed, as well as its shutter, while a vent-hole near the ground is opened by drawing its cord, which passes over a pulley. After a few minutes, when the sulphur is fully kindled, that vent-hole must be almost entirely shut, by relaxing the cord; when the whole apparatus is to be let alone for a sufficient time.

The object of the preceding precautions is to prevent the sulphurous acid gas escaping from the chamber by the seams of the principal doorway. This is secured by closing it imperfectly, so that it may admit of the passage of somewhat more air than can enter by the upper seams, and the smallest quantity of fresh air that can support the combustion. The velocity of the current of air may be increased at pleasure, by enlarging the under vent-hole a little, and quickening the fire of the draught-stove.

Before opening the entrance door of the apartment, for the discharge of the goods, a small fire must be lighted in the draught furnace, the vent-hole must be thrown entirely open, and the sliding shutter of the door must be slid up, gradually more and more every quarter of an hour, and finally left wide open for a proper time. By this means the air of the chamber will become soon respirable.

SULPHURETTED HYDROGEN, is a gas, composed of one part of hydrogen and sixteen parts of sulphur, by weight. Its specific gravity is 1.1912, compared to air = 1.0000. It is the active constituent of the sulphureous mineral waters. When breathed, it is very deleterious to animal life; and being nearly twice as dense as air, it may be poured from its generating bottle into cavities; a scheme successfully employed by M. Thenard to destroy rats in their holes.

SULPHURIC ACID, *Vitriolic Acid*, or *Oil of Vitriol* (*Acid sulfurique*, Fr.; *Schwefelsäure*, Germ.). This important product, the agent of many chemical operations, was formerly procured by the distillation of dried sulphate of iron, called *green vitriol*, whence the corrosive liquid which came over, having an oily consistence, was denominated oil of vitriol. This method has been superseded in Great Britain, France, and most other countries, by the combustion of sulphur along with nitre, in large leaden chambers; but as the former process, which is still practised at Bleyl in Bohemia, and Nordhausen in Saxony, gives birth to some interesting results, I shall describe it briefly.

Into a long horizontal furnace, or gallery of brickwork, a series of earthenware retorts, of a pear shape, is arranged, with curved necks fitted into stoneware bottles or condensers. Each retort is charged with sulphate of iron, which has been previously heated to moderate redness. The first product of the distillation, a slightly acidulous phlegm, is allowed to escape; then the retort and receiver are securely luted together. The fire is now raised, and urged briskly for 36 hours, whereby the strong sulphuric acid is expelled, in the form of heavy white vapours, which condense in the cold receiver into an oily-looking liquid. The latter portions, when received in a separate refrigerator, frequently concrete into a crystalline mass, formerly called *glacial oil of vitriol*. About 64 pounds of strong acid may be obtained from 600 pounds of copperas. It is brown-coloured; and varies in specific gravity from 1.842 to 1.896. Its boiling point is so low as 120° Fahr. When re-distilled in a glass retort, into a receiver surrounded with ice, a very moderate heat sends over white fumes, which condense into a soft solid, in silky filaments, like asbestos, tough, and difficult to cut. When this is exposed to

the air, it emits copious fumes of sulphuric (not sulphurous) acid. It burns holes in paper as rapidly as a red-hot iron. Dropped in small quantities into water, it excites a hissing noise, like ignited metal; and in larger quantities, it occasions an explosion. By dropping a fragment of it into a poised phial containing water, and stopping instantly, to prevent the ejection of liquid, by the ebullition which always ensues, I got a dilute acid, containing a known portion of the solid acid, from the specific gravity of which, as well as from its saturating power, I ascertained that the above solid sulphuric acid was truly anhydrous (*void of water*), consisting of 1 equivalent proportion of sulphur, and 3 of oxygen; or, by weight, of 16 of the former, and 24 of the latter. This acid makes a red solution of indigo.

The production of sulphuric acid from sulphur and nitre may be elegantly illustrated by means of a glass globe with a stoppered hole at its side, and four bent glass tubes inserted into a leaden cap in its upper orifice. The first tube is to be connected with a heated matrass, disengaging sulphurous acid from copper filings and sulphuric acid; the second with a retort, disengaging more slowly deutoxide of azote (nitric oxide) from copper filings and nitric acid; the third with a vessel for furnishing steam in a moderate current towards the end of the process, when no water has been previously admitted into the balloon; the fourth tube may be upright, and terminate in a small funnel. Through the opening in the side of the globe, atmospheric air is to be admitted from time to time, by removing the stopper; after which, the residuary lighter azote may be allowed to escape by the funnel orifice.

The nitric oxide first absorbs oxygen from the air, becomes, in consequence, nitrous acid vapour, which giving up one third of its oxygen to the sulphurous acid, converts this, with the aid of water, into sulphuric acid, while itself returning to the state of nitric oxide, is again qualified to take oxygen from the air, and to transfer it to the sulphurous acid gas; and thus in perpetual rotation. These oxygenating and disoxygenating processes continue until nearly the whole oxygen of the atmospheric air contained in the globe is consumed. Were there little aqueous vapour present, those gases would soon cease to operate upon each other; for though the nitric oxide became nitrous acid, this would oxygenate little of the sulphurous acid, because the three substances would condense into white crystals upon the sides of the balloon, like hoar frost upon a window-pane in winter. These indicate a deficiency of aqueous vapour, and an excess of nitrous acid. On the admission of steam, the crystals disappear, the sulphuric acid is liquefied, the nitrous acid is converted into nitric acid and nitric oxide; the former of which combines with the water, while the latter is converted by the atmospheric oxygen into nitrous acid vapour. A certain quantity of water is therefore requisite to prevent the formation of that crystalline compound, which condenses the nitrous acid, and renders it inoperative in transforming fresh portions of sulphurous acid into sulphuric. On these principles alone is it possible to oxygenate the sulphurous acid, by the nitrous acid resuming and surrendering a dose of oxygen, in perpetual alternation.

It was M. M. Clement and Desormes who first had the sagacity to trace these complicated changes. They showed that nitrous acid gas and sulphurous acid gas mixed, react on each other through the intervention of moisture; that there resulted thence a combination of sulphuric acid, deutoxide of azote (nitrous gas), and water; that this crystalline compound was instantly destroyed by more water, with the separation of the sulphuric acid in a liquid state, and the disengagement of nitrous gas; that this gas re-constituted nitrous acid at the expense of the atmospheric oxygen of the leaden chamber, and thus brought matters to their primary condition. From this point, starting again, the particles of sulphur in the sulphurous acid, through the agency of water, became fully oxygenated by the nitrous acid, and fell down in heavy drops of sulphuric acid, while the nitrous gas derived from the nitrous acid, had again recourse to the air for its lost dose of oxygen. This beautiful interchange of the oxygenous principle was found to go on, in their experiments, till either the sulphurous acid, or oxygen in the air, was exhausted.

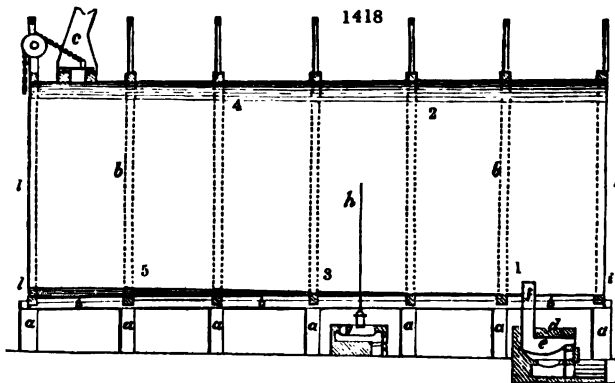
They verified this proposition, with regard to what occurs in sulphuric acid chambers, by mixing in a crystal globe the three substances, deutoxide of azote, sulphurous acid, and atmospheric air. The immediate production of red vapours indicated the transformation of the deutoxide into nitrous acid gas; and now the introduction of a very little water caused the proper *reaction*, for opaque vapours rose, which deposited white star-form crystals on the surface of the glass. The gases were once more transparent and colourless; but another addition of water melted these crystals with effervescence, when ruddy vapours appeared. In this manner the phenomena were made to alternate, till the oxygen of the included air was expended, or all the sulphurous acid was converted into sulphuric. The residuary gases were found to be nitrous acid gas, and azote, without sulphurous acid gas; while unctuous sulphuric acid bedewed the inner surface of the globe. Hence, they justly concluded their new theory of the manufacture of oil of vitriol to be demonstrated.

In consequence of their discovery, the manufacture of this acid has received such

improvements, that a nearly double product of it may now be obtained from the same weight of materials. Indeed, the economy may be reckoned to be much greater; for one half of the more costly ingredient, the nitre, formerly employed with a given weight of sulphur, suffices at present.

In the manufacture of sulphuric acid upon the great scale, two different systems of working were long prevalent; the intermittent or periodical, and the continuous or uniform. Both were carried on in large leaden chambers. In the former, the chambers were closed during the period of combustion and gaseous combination, but were opened from time to time to introduce fresh atmospheric air. This method is, I believe, generally abandoned now, on account of the difficulties and delays attending it, though it afforded large products in skilful hands. In the latter, a continuous current of air is allowed to enter at the oven in front of the chamber for the combustion of the sulphur, and there is a constant escape of nitrogen gas, with a little sulphurous acid gas, at the remote end of the roof.

Fig. 1418. represents a sulphuric acid chamber. *a, a*, are the brick or stone pillars upon which it rests; *b, b*, are the sustaining wooden beams or joists; *c*, is the chimney for the discharge of the nitrogen; *d*, is the roof, and *e*, the sole of the hearth for the combustion of the sulphur; *f*, is the cylindrical tunnel, or pipe of lead or cast iron, for conducting the gasiform materials into the chamber; *g*, is the steam-boiler; and *h*, the steam-pipe. That plan is variously modified, by different oil-of-vitriol makers in this country and in France. Very frequently, the oven *e, d*, is not situated under the chamber, but is built at the end of it, as at *i*, and arched over with brick, the crown being 9 inches thick. The pipe *f*, 18 inches in diameter, is then placed outside of the chamber, being inserted into a brick chimney, and, turning rectangularly, enters it opposite *k*. The sole of the hearth *e*, is a thick plate of cast iron (not hollowed as shown in the figure), 5 or 6 feet long, and 3 or 4 broad, with a small fireplace constructed beneath it, whose smoke-flue runs outwards, under the floor, to the side wall of the building. The oven is in this case about 2 feet in height, from the sole to the roof; and it has an iron door, about 12 inches by 15, which slides up and down in a tightly-fitted iron



frame. This door is frequently placed in the side of the oven, parallel to the long side of the leaden chamber. A stout collar of lead is bolted to the chamber, where the pipe enters it. At the middle of the side of the chamber, about 2 feet above the ground, a leaden trough is fixed, which serves as

a syphon-funnel and water-trap for introducing water to the acid gases.

Several manufacturers divide the chamber into a series of rectangular compartments, by parallel leaden screens, 10 or 12 feet asunder, and allow these compartments to communicate by a narrow opening, or a hole 1 foot square, in the top and bottom of each screen alternately. Thus the fumes, which enter from the chimney-pipe over *h*, will be forced, by the screen at *b*, to descend to *l*, and pass through the opening there, to get into the second compartment, whence they will escape near the top at *2*, thus circulating up and down, so as to occasion a complete agitation and intermixture of their heterogeneous particles. Into the side of the chamber, opposite to the centre of each compartment, a lead pipe enters, and proceeds towards the middle of the area, terminating in a narrow orifice, for discharging a jet of high-pressure steam from a boiler loaded with 40 pounds upon the square inch. This boiler should be placed under a shed exterior to the building. It deserves to be noted, that the incessant tremors produced in this pipe by the escape of the steam, cause the orifice to contract, and eventually to close almost entirely, just as the point of a glass tube does when exposed directly to the flame of a blowpipe. Provision should therefore be made against this event, by the chemical engineer.

Equidistant between the middle point and each end of the chamber, two round holes are cut out in its side, about 16 inches in diameter, and 2 feet from the floor; the sheet

lead being folded back over the face of the strong deals which strengthen the chamber in that place. The edges of the holes are bevelled outwards, so as to fit a large conical plug of wood faced with lead, called a man-hole door. One or other of these doors is opened from time to time, to allow the superintendent to inspect the process, or workmen to enter, after the chamber is well ventilated, for the purpose of making repairs. The joists or tie-beams, that bind the rafters of the roof of both the leaden chamber and the house, must be at least 7 inches deep, by 3 broad, and of such length as to have their ends supported upon the outer wall, or the columnar supports of the roof, in case a number of chambers are enclosed together in parallel ranges under a vast shed. These beams, which lie two feet apart, suspend the leaden roof, by means of leaden straps, soldered to its upper surface and edges. The sides of the chamber are sustained by means of similar leaden straps affixed to the wooden posts (uprights), 4 inches broad by 3 thick, placed two or three feet apart along the sides of the chamber; resting on the ground below, and mortised into the tie-beams above. Some chambers rest upon a sand-floor; but they are preferably placed upon wooden joists, supported by pillars stretching over an open area, as shown in the figure, into which the workmen may descend readily, to examine the bottom.

The outlet *c*, on the top of the chamber, is sometimes joined to a long pipe of lead laid nearly horizontally, with a slight inclination upwards, along the roof, for favouring the condensation and return of acid matter.

At the extremity *l*, of the chamber, which, having a downward slope of 1 inch in every 20 feet, should stand from 3 to 6 inches (according to its length) lower than *i*, one leg of an inverted syphon pipe is fixed by fusion, into which the liquid of the chamber passing, will show by its altitude the depth on the bottom within. From the cup-shaped orifice of that bent-up pipe, the acid of the chamber is drawn off by an ordinary leaden syphon into the concentration pans.

The sheet lead of which the sides and top are made, should weigh from 5 to 6 pounds per square foot; that of the bottom should be nearly of double thickness.

Having now detailed, with sufficient minuteness, the construction of the chamber, I shall next describe the mode of operating with it. There are at least two plans at present in use for burning the sulphur continuously in the oven. In the one, the sulphur is laid on the hearth *e*, (or rather on the flat hearth in the separate oven, above described,) and is kindled by a slight fire placed under it; which fire, however, is allowed to go out after the first day, because the oven becomes by that time sufficiently heated by the sulphur flames to carry on the subsequent combustion. Upon the hearth, an iron tripod is set, supporting, a few inches above it, a hemispherical cast-iron bowl (basin) charged with nitre and its decomposing proportion of strong sulphuric acid. In the other plan, 12 parts of bruised sulphur, and 1 of nitre, are mixed in a leaden trough on the floor with 1 of strong sulphuric acid, and the mixture is shovelled through the sliding iron door upon the hot hearth. The successive charges of sulphur are proportioned, of course, to the size of the chamber. In one of the largest, which is 120 feet long, 20 broad, and 16 high, 12 cwt. are burned in the course of 24 hours, divided into 6 charges, every fourth hour, of 2 cwt. each. In chambers of one-sixth greater capacity, containing 1400 metres cube, 1 ton of sulphur is burned in 24 hours. This immense production was first introduced at Chaunay and Dieuze, under the management of M. Clement-Desormes. The bottom of the chamber should be covered at first with a thin stratum of sulphuric acid, of spec. grav. 1.07, which decomposes nitrous acid into oxygen and nitrous gas; but not with mere water, which would absorb the nitrous acid vapours, and withdraw them from their aerial sphere of action. The vapour of nitric acid, disengaged from the nitre on the hearth of the oven, when brought into intimate contact with the sulphurous acid, either gives up oxygen to it, becomes itself nitrous gas, and converts it into sulphuric acid; or combines with the sulphurous acid into the crystalline compound above described, which, the moment it meets with moisture, is decomposed into sulphuric acid and nitrous gas. The atmospheric oxygen of the chamber immediately reconverts this gas into nitrous or nitric acid fumes, which are again ready, with the co-operation of sulphurous acid gas and aqueous vapour, to produce fresh quantities of hydrous sulphuric acid (oil of vitriol) and nitrous gas. At low temperatures, this curious play of chemical affinities has a great tendency to form the crystalline compound, and to deposit it in a crust of considerable thickness (from one-half to one inch) on the sides of the chamber, so as to render the process inoperative. A circumstance of this kind occurred, in a very striking manner, during winter, in a manufacture of oil of vitriol in Russia; and it has sometimes occurred, to a moderate extent, in Scotland. It is called, at Marseilles, the *maladie des chambres*. It may be certainly prevented, by maintaining the interior of the chamber, by a jet of steam, at a temperature of 100° F. When these crystals fall into the dilute acid at the bottom, they are decomposed with a violent effervescence, and a hissing gurgling noise, somewhat like that of a tun of beer in brisk fermentation.

M. Clement-Desormes demonstrated the proposition relative to the influence of temperature by a decisive experiment. He took a glass globe, furnished with three tubulures, and put a bit of ice into it. Through the first opening he then introduced sulphurous acid gas; through the second, oxygen; and through the third, nitrous gas (deutoxide of azote). While the globe was kept cool, by being plunged in iced water, no sulphuric acid was formed, though all the ingredients essential to its production were present. But on exposing the globe to a temperature of 100° Fahr., the four bodies began immediately to react on each other, and oil of vitriol was condensed in visible strice.

The introduction of steam is a modern invention, which has vastly facilitated and increased the production of oil of vitriol. It serves, by powerful agitation, not only to mix the different gaseous molecules intimately together, but to impel them against each other, and thus bring them within the sphere of their mutual chemical attraction. This is its mechanical effect. Its chemical agency is still more important. By supplying moisture at every point of the immense included space, it determines the formation of hydrous sulphuric acid, from the compound of nitric, nitrous, sulphurous, and dry sulphuric acids. No sooner is this reaction accomplished, than the nitrous gas resumes its oxygen, from the continuous atmospherical current, and becomes again fit to operate a like round of transmutations with sulphurous acid, steam, and oxygen. The nitrogen (azote), which ought to be the only residuum in a perfectly regulated vitriol chamber, escapes, by its relative lightness, at the opening *c*, in the roof, or, more properly speaking, is displaced by the influx of the heavier gases at the entrance-pipe.

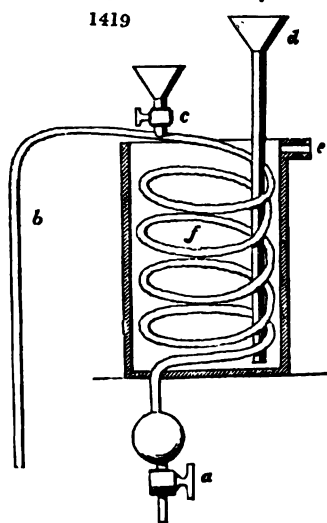
On the intermittent plan, after the consumption of each charge, and condensation of the product, the chamber was opened, and freely ventilated, so as to expel the residuary azote, and replenish it with fresh atmospheric air. In this system there were four distinct stages or periods:—1. Combustion for two hours; 2. Admission of steam, and settling, for an hour and a half; 3. Conversion, for three hours, during which interval the drops of strong acid were heard falling like heavy hailstones on the bottom; 4. Purging of the chamber, for three quarters of an hour.

By the continuous method, sulphuric acid may be currently obtained in the chambers, of the specific gravity 1.350, or 1.450 at most; for, when stronger, it absorbs and retains permanently much nitrous acid gas; but by the intermittent, so dense as 1.550, or even 1.620; whence in a district where fuel is high priced, as near Paris, this method recommended itself by economy in the concentration of the acid. In Great Britain, and even in most parts of France, however, where time, workmen's wages, and interest of capital, are the paramount considerations, manufacturers do not find it for their interest in general to raise the density of the acid in the chambers above 1.400, or at most 1.500; as the further increase goes on at a retarded rate, and its concentration from 1.400 to 1.600, in leaden pans, costs very little.

At about the specific gravity of 1.35, in Great Britain, the liquid of the chambers is run off by the syphon above described, into a leaden gutter or spout, which discharges it into a series of rectangular vessels made of large sheets of lead, of 12 or 14 lbs. to the square foot, simply folded up at the angles into pans 8 or 10 inches deep, resting upon a grate made of a pretty close row of wrought-iron bars of considerable strength, under which the flame of a furnace plays. Where coals are very cheap, each pan may have a separate fire; but where they are somewhat dear, the flame, after passing under the lowest pan of the range, which contains the strongest acid (at about 1.600), proceeds upwards with a slight slope to heat the pans of weaker acid, which, as it concentrates, is gradually run down by syphons to replenish the lower pans, in proportion as their aqueous matter is dissipated. The 3 or 4 pans constituting the range are thus placed in a straight line, but each at a different level, terrace-like; *en gradins*, as the French say.

When the acid has thereby acquired the density of 1.650, or 1.700 at most, it must be removed from the leaden evaporators, because, when of greater strength, it would begin to corrode them; and it is transferred into leaden coolers, or run through a long refrigeratory worm-pipe surrounded by cold water. In this state it is introduced into glass or platinum retorts, to undergo a final concentration, up to the specific gravity of 1.842, or even occasionally 1.845, in consequence of slight saline impurities. When glass retorts are used, they are set in a long sand-bath over a gallery furnace, resting on fire-tiles, under which a powerful flame plays; and as the fume gradually ascends from the fire-place, near to which it is most distant from the tiles, to the remoter end, the heat acts with tolerable equality on the first and last retort in the range. When platinum stills are employed, they are fitted into the inside of cast-iron pots, which protect the thin bottom and sides of the precious metal. The fire being applied directly to the iron, causes a safe, rapid, and economical concentration of the acid. The iron pots, with their platinum interior, filled with concentrated boiling-hot oil of vitriol, are lifted out of the fire-seat by tackle, and let down into a cistern of cold water, to effect the speedy refrigeration of the acid, and facilitate its transvasion into carboys packed in osier baskets lined with straw. Sometimes, however, the acid is cooled by running it

slowly off through a long platinum syphon, surrounded by another pipe filled with cold water. Fig. 1419. shows my contrivance for this purpose.



The under stopcock *a*, being shut, and the leg *b*, being plunged to nearly the bottom of the still, the worm is to be filled with concentrated cold acid through the funnel *c*. If that stopcock is now shut, and *a* opened, the acid will flow out in such quantity as to rarefy the small portion of air in the upper part of the pipe *b*, sufficiently to make the hot acid rise up over the bend, and set the syphon in action. The flow of the fluid is to be so regulated by the stopcock *a*, that it may be greatly cooled in its passage by the surrounding cold water in the vessel *f*, which may be replenished by means of the tube and funnel *d*, and overflow at *e*.

A manufacturer of acid in Scotland, who burns in each chamber 210 pounds of sulphur in 24 hours, being at the rate of 420 pounds for 20,000 cubic feet (= nearly 2000 metres cube) has a product of nearly 3 pounds of concentrated oil of vitriol for every pound of sulphur and twelfth of a pound of nitre. The advantage of his process results, I conceive, from the lower concentration of the acid in the chambers, which favours its more rapid production.

The platinum retort admits of from 4 to 6 operations in a day, when it is well mounted and managed. It has a capital of platinum, furnished

with a short neck, which conducts the disengaged vapours into a lead worm of condensation; and the liquid thus obtained is returned into the lead pans. Great care must be taken to prevent any particles of lead from getting into the platinum vessel, since at the temperature of boiling sulphuric acid, the lead unites with the precious metal, and thus causes holes in the retort. These must be repaired by soldering-on a plate of platinum with gold.

Before the separate oven or hearth for burning the sulphur in contact with the nitre was adopted, this combustible mixture was introduced into the chamber itself, spread on iron trays or earthen pans, supported above the water on iron stands. But this plan was very laborious and unproductive. It is no longer followed.

One of the characters of the good quality of sulphuric acid, is its dissolving indigo without altering its fine blue colour.

Sulphuric acid, when well prepared, is a colourless and inodorous liquid, of an oily aspect, possessing a specific gravity, in its most concentrated state, of 1.842, when re-distilled, but as found in commerce, of 1.845. It is eminently acid and corrosive, so that a single drop will communicate the power of reddening litmus to a gallon of water, and will produce an ulcer of the skin when allowed to remain upon it. If swallowed in its strongest state, in even a small quantity, it acts so furiously on the throat and stomach as to cause intolerable agony and speedy death. Watery diluents, mixed with chalk or magnesia, are the readiest antidotes. At a temperature of about 600° F., or a few degrees below the melting point of lead, it boils and distils over like water. This is the best method of procuring sulphuric acid free from the saline and metallic matters with which it is sometimes contaminated.

The affinity of sulphuric acid for water is so strong that, when exposed in an open saucer, it imbibes one-third of its weight from the atmosphere in 24 hours, and fully six times its weight in a few months. Hence it should be kept excluded from the air. If four parts, by weight, of the strongest acid be suddenly mixed with one part of water, both being at 50° F., the temperature of the mixture will rise to 300°; while, on the other hand, if four parts of ice be mixed with one of sulphuric acid, they immediately liquefy and sink the thermometer to 4° below zero. From the great attraction existing between this acid and water, a saucer of it is employed to effect the rapid condensation of aqueous vapour as it exhales from a cup of water placed over it; both standing under the exhausted receiver of an air-pump. By the cold produced by this unchecked evaporation in vacuo, the water is speedily frozen.

To determine the purity of sulphuric acid, let it be slowly heated to the boiling point of water, and if any volatile acid matter be present, it will evaporate, with its characteristic smell. The presence of saline impurity, which is the common one, is discovered by evaporating a given weight of it in a small capsule of platinum placed on red-hotinders. If more than two grains remain out of 500, the acid may be reckoned to be

impure. The best test for sulphuric acid, and the soluble salts into which it enters, is the nitrate of baryta, of which 182 parts are equivalent to 49 of the strongest liquid acid, or to 40 of the dry, as it exists in crystallized sulphate of potassa. One twenty thousandth part of a grain of the acid may be detected by the grayish-white cloud which baryta forms with it. 100 parts of the concentrated acid are neutralized by 143 parts of dry carbonate of potassa, and by 110 of dry carbonate of soda, both perfectly pure.

Of all the acids, the sulphuric is most extensively used in the arts, and is, in fact, the primary agent for obtaining almost all the others, by disengaging them from their saline combinations. In this way nitric, muriatic, tartaric, acetic, and many other acids, are procured. It is employed in the direct formation of alum, of the sulphates of copper, zinc, potassa, soda; in that of sulphuric ether, of sugar by the saccharification of starch, and in the preparation of phosphorus, &c. It serves also for opening the pores of skins in tanning, for clearing the surfaces of metals, for determining the nature of several salts by the acid characters that are disengaged, &c.

According to the analysis of Dr. Thomson, the crystalline compound deposited occasionally in the leaden chambers above described consists of—

| | | | | |
|-----------------|---------------------|------------------|---|--------------------|
| Sulphurous acid | 0·6387, or 3 atoms. | Water | - | 0·0733, or 1 atom. |
| Sulphuric acid | 0·5290 | Sulphate of lead | - | 0·0140. |
| Nitric acid | - 0·3450 | | | |
| | 2 | | | |
| | 1 atom. | | | |

He admits that the proportion of water is a little uncertain; and that the presence of sulphurous acid was not proved by direct analysis. When heated with water, the crystalline matter disengages nitrous gas in abundance; lets fall some sulphate of lead; and the liquid is found to be sulphuric acid. When heated without water, it is decomposed with emission of nitrous gas and fuming nitric acid; leaving a liquid which mixed with water, produces a brisk effervescence, consisting chiefly of nitrous gas.

A valuable improvement of the process for manufacturing this fundamental chemical agent has been contrived by M. Gay Lussac, and made the subject of a patent in this country by his agent M. Sautter. It consists in causing the waste gas of the vitriol chamber to ascend through the *chemical cascade* of M. Clement Desormes, and to encounter there a stream of sulphuric acid of specific gravity 1·750. The nitrous acid gas, which is in a well regulated chamber always slightly redundant, is perfectly absorbed by the said sulphuric acid; which, thus impregnated, is made to trickle down through another cascade, up through which passes a current of sulphurous acid, from the combustion of sulphur in a little adjoining chamber. The condensed nitrous acid gas is thereby immediately transformed into nitrous gas (deutoxide of azote), which is transmitted from this second cascade into the large vitriol chamber, and there exercises its well known reaction upon its aeriform contents. The economy thus effected in the sulphuric acid manufacture is such that for 100 parts of sulphur 3 of nitrate of soda will suffice, instead of 9 or 10 as usually consumed.

Upon the formation of sulphated nitrous gas ($\text{NO}^2, 3\text{SO}^2, 2\text{HO}$), and its combination with oil of vitriol, the manufacture of hydrated sulphuric acid is founded. Either sulphur is burned in mixture with about one-ninth of saltpetre; whence along with sulphuric acid gas, nitrous oxide gas is disengaged, while sulphate of potash remains; thus $\text{K O}, \text{N O}^2 + \text{S} = \text{SO}^2 + \text{N O}^2, \text{K O}$. 2. Or, nitric acid in the fluid or vaporous form may be present in the lead-chamber, into which the sulphurous acid gas passes, in consequence of placing in the flames of the sulphur a pan charged with a mixture of sulphuric acid and nitre or nitrate of soda. This nitric acid being decomposed by a portion of the sulphurous acid, there will result sulphuric acid and nitrous gas. By the mutual re-action of the sulphurous and nitric acids, sulphuric acid and nitrous gas will be produced; $\text{N O}^2 + 3\text{SO} = \text{NO}^2 + 3\text{SO}^2$. 3. Or, by heating sugar or starch with nitric acid, the mixture of nitrous gas and nitrous acid vapour which results may be thrown into the chamber among the sulphurous acid. In any one of these three cases, sulphurous acid gas, nitrous acid vapours (proceeding from the mixture of nitrous oxide and atmospheric oxygen) and steam are mingled together; whence arises the crystalline compound of sulphated nitrous oxide with sulphuric acid, which compound subsides in white clouds to the bottom of the chamber, and dissolves in the dilute oil of vitriol placed there, into sulphuric acid, with disengagement of nitrous gas. This gas now forms, with the remaining atmospheric oxygen, nitrous acid vapours once more, which condense a fresh portion of sulphurous acid gas into the above crystalline compound; and thus in perpetual alternation.

Sulphurous acid gas does not act upon nitrous gas, not even upon the nitrous acid vapour produced by the admission of oxygen, if water be absent; but the moment that a little steam is admitted the crystalline compound is condensed. The presence of

much sulphuric acid favours the formation of the sulphated nitrous gas. These crystals are decomposed by tepid water with disengagement of nitrous gas, which seizes the oxygen present and becomes nitrous acid (hyponitric of many chemists).

Sanitary motives alone induced the makers of soda to condense their waste muriatic acid in the first instance; though they now discover its worth as a means of manufacturing chloride of lime, and would not again return to the nuisance-creating system if they might. In time, no doubt, the copper smelter will also be compelled to arrest the poisonous fumes now so wantonly evolved; and then he too will find a profit in that which, at present, only injures his neighbour. It is with individual interests as with physical bodies, the largest are the most difficult to move from any established position. Not many years ago, all the sulphuric acid used in this country was made from sulphur alone; and, although scientific men had pointed out iron pyrites as an abundant indigenous source for the generation of this acid, yet no attention whatever was given to this seemingly valueless information. Folly, however, achieved that which wisdom could not reach; and the infatuated cupidity of a Sicilian king compelled our manufacturers to lend a willing ear to the voice of science, and seek at home that which a prohibitive export duty prevented them from obtaining abroad. Their eyes were at length opened, and, too late, the King of Sicily saw his error: for, though the excessive duty on sulphur has since been removed, it has not only failed to put down the use of iron pyrites, but the best informed authorities are decidedly of opinion, that this latter will eventually abolish the employment of sulphur, and that Ireland, and not Sicily, will furnish the essential element for the fabrication of nearly all our sulphuric acid. There is, however, one very serious drawback to the general use of iron pyrites for such a purpose, and that is, the presence of arsenic in all the acid thus made. This objection is fatal at present, and the combined agency of mechanical and chemical genius alone can relieve this important manufacture from so great an obstacle. Means have indeed been devised for removing the arsenic from the acid after the formation of the latter; but those acquainted with the practical working of sulphuric acid well know that such a project is futile and impossible on the large scale. There are, in fact, but two modes of dealing with the difficulty, the one being to prevent the volatilization of the arsenic at all, by mixing the pyrites with some suitable ingredient ere it is thrown into the furnace; and the other, to remove the arsenic from the sulphurous acid before it reaches the chamber of condensation. The first would be the simplest plan; but in the existing state of science, can scarcely be hoped for. The last, however, is not by any means beyond the scope of perseverance and ingenuity. It must be borne in mind, that, though the arsenic, being in the form of arsenious acid when it leaves the furnace with the sulphurous acid, is in the gaseous state, yet a very trifling reduction of temperature suffices to convert it into a solid powder; in which condition it is merely carried onwards, mechanically, by the current of sulphurous acid; and thus reaches the leaden chamber. The mixture, therefore, resembles that of turbid water; and, bearing this analogy in mind, we shall now proceed to describe the pyritic process of making sulphuric acid,—adding, as we go on, a hint at the proper place for arresting the arsenious fumes, and thus producing a pure and satisfactory acid, equal to that obtained from Sicilian sulphur. The furnace employed for roasting iron pyrites is very peculiar, but essentially consists of an inverted cone, with, of course, a small area of fire-grate, in proportion to the cubical contents of the furnace,—the object of this being, to prevent the surplus passage of air through the furnace, and cause the sublimed sulphur to burn only at the upper part of the mass, where there are two or more holes for the supply of air, duly provided with stoppers, to regulate the combustion above with regard to that below. Thus, at starting, the principal effect of the lower heat is simply to decompose the bisulphate of iron, and expel one half of its sulphur; and at this stage, the upper openings of the furnace are all requisite, to ensure the combustion of this volatilized sulphur; but so soon as the bisulphuret of iron has been converted into the proto-sulphuret, then the upper openings are no longer useful, but must be closed, so as to compel the whole of the air to pass through the red-hot protosulphuret, and thus form sulphurous acid and oxide of iron,—the latter of which is ultimately withdrawn as a waste product. An iron pan, containing nitrate of soda, is usually placed in the common flue of a number of these furnaces, to supply nitric oxide gas; and the whole of the volatile products are made to pass through a considerable length of tubing, subjected to the refrigerating effect of the air, so as to cool the gases prior to their introduction into the chamber of condensation.

As the subsequent processes are the same as those adopted with regard to Sicilian sulphur, they will be most conveniently noticed when treating of the employment of that substance; and therefore we now proceed to consider the question of removing from the volatile mixture the arsenical matters which it holds in suspension; for, during the passage of this mixture through the refrigerating tube, above described, the arsenious acid is really solidified: whilst the sulphurous acid, being a permanently elastic gas,

suffers but a trifling contraction in its bulk. We requested attention to the case of turbid water as a simile from whence to acquire a correct notion of the kind of mixture passing into the condensing chamber; and this suggests also the means of purification. With turbid water filtration might indeed be resorted to, which is inapplicable to our difficulty; but there is another mode in which water is purified by nature on the large scale, and that is, by deposition, or attraction of gravitation. For this purpose absolute rest is not necessary; as may be seen on examining the water running into and out of a lake in spring or autumn. It enters foul and muddy; but, at its exit, is clear and pellucid as crystal. This is precisely the object desired with respect to the gaseous products given off from a pyrites furnace, and may be accomplished in precisely the same way. Let a gaseous lake, or large chamber in brickwork, be interposed between the refrigerating tube and the condensation-chamber, through which, of course, the contaminated sulphurous acid would flow, but so slowly as to deposit, like the water in the lake, the mechanical impurities suspended in it, and thus pass pure and undefiled into the leaden chamber, possessing now all the properties and uses of that obtained by the combustion of pure sulphur. The size of this gaseous lake or arsenical precipitator, as it might be termed, would require adjustment according to the area of the entrance tube and the velocity of the current, but need not, perhaps, be more than one half of the cubical contents of the leaden chamber, especially if the gas entered below and issued from the top.

We are now arrived at the point where the modes of using pyrites and sulphur unite: consequently, it will be necessary to examine the early steps in the employment of this latter. These are quite as simple as the management of a common fire,—for the sulphur is merely thrown into a kind of oven, provided with a door capable of regulating the admission of air; and near to this door, but within the oven, an iron pot containing nitrate of soda is placed, the contents of which are in the proportion of about 6 per cent. of the nitrate to a given amount of sulphur. The sulphur having been once lighted, combustion goes on continuously, and the volatile products, after passing through the refrigerating tube, ultimately enter the condensing chamber; here they are met by a current of steam, which causes the compound of sulphur, nitrogen, and oxygen, to fall to the bottom of the chamber, and, in combining with the water there placed, decomposition ensues, attended with the formation of sulphuric acid and nitric oxide gas; the former of which remains in solution, whilst the latter rises, and uniting to a fresh portion of sulphurous acid, and to part of the oxygen in the chamber, again falls, and is decomposed as before, until either no more sulphurous acid or oxygen gas remains in the chamber, the latter of which circumstances would imply bad management, and is probably the cause of what is termed “chamber sickness.” This condensation process lasts many hours, and sometimes even days are spent in its completion, the workmen judging of its progress by the colour of the fumes displayed on opening a small door or aperture near the bottom of the chamber: by which they also form an opinion as to the excess or deficiency of nitrous vapour, and apply the appropriate remedy in the combustion furnace. When the water on the floor of the chamber has received a certain amount of sulphuric acid, it ceases to act favourably upon the gaseous mixture, and is therefore withdrawn. For many purposes in the arts, such acid is quite strong enough; and hence, under the name “chamber acid,” it is extensively employed. But, to complete its character as oil of vitriol, this chamber acid is evaporated, first in leaden vessels, but ultimately in a platinum boiler, set over the naked fire, and provided with a head or cover, and a syphon tube, all in platinum: by the syphon tube the operator is enabled to draw off the concentrated acid when sufficiently evaporated. A boiler of this kind is kept constantly in action after the fire has been once lighted; the only cause of stoppage being the necessity for repairs, which are vastly more frequent than might be imagined, considering the imperishable nature of the metal employed in the construction of these boilers. Selenious acid is thought to be the corroding agent, and perhaps correctly, as chlorine is quite out of the question.

Concentrated dry sulphuric acid of Nordhausen. M. Paul Gilbert Prelier, of Paris, has patented the following plan of manufacturing dry sulphuric acid. He employs 100 parts of sulphate of soda, 2 parts of sulphate of potash, and 2 parts of sulphate of lime. The mixture is put into freestone retorts (*cornues de gres*?) set in a suitable furnace; then by means of a bent glass tube, the acid is introduced into the retorts, and heat is gradually applied. Shortly after the application of heat, drops of water will fall from the retorts, then acidulated water, followed by acid at 40°, 50°, and 66° Baumé, and finally by acid which fumes or smokes. To enable the operator to judge correctly of the progress of the operation, vessels containing water are placed to receive the drops of acid; and when each drop produces a sound resembling that which a red-hot iron would cause in the water, the dry acid is produced, and is to be collected. Nordhausen acid is obtained, he says, by introducing oil of vitriol, at 66° Baumé, into the vessels which receive the dry

acid. But this Nordhausen acid is colourless, and pure. He does not specify the quantity of oil of vitriol that he introduces at first along with the sulphates.

Anhydrous Sulphuric Acid. Highly concentrated oil of vitriol must be mixed with dry phosphoric acid, obtained by the combustion of phosphorus beneath a receiver placed over a plate of glass, allowing free access for dry atmospheric air. On mixing the two acids, a strong chemical action ensues, with considerable elevation of temperature; and therefore the mixture should be made in a retort surrounded by a freezing mixture, the phosphoric acid being previously cooled, and the cold oil of vitriol being gradually added; allowing the heat to subside after each addition. When a quantity of oil of vitriol equal to about two-thirds the weight of the phosphoric acid has been thus added, the mixture, which has acquired a dark brown colour, is removed from the cooling bath, and a receiver is placed there, to which the retort has been adapted. A gentle heat is now applied to the retort, and dense white vapours soon begin to pass into the receiver, where they are condensed by the cold. In this way a considerable quantity of beautiful white silky crystals are obtained. With careful manipulation, an ounce of phosphorus, converted into anhydrous acid by combustion in dry air, will yield one ounce of anhydrous sulphuric acid. If a few drops of water be added, a dangerous explosion ensues. — *Barreswill.*

The following TABLE shows the quantity of concentrated and dry sulphuric acid in 100 parts of dilute, at different densities, by my experiments, published in the Quarterly Journal of Science, for October, 1817: —

| Liquid. | Sp. Grav. | Dry. | Liquid. | Sp. Grav. | Dry. | Liquid. | Sp. Grav. | Dry. |
|---------|-----------|-------|---------|-----------|-------|---------|-----------|--------|
| 100 | 1·8460 | 81·54 | 66 | 1·5503 | 53·82 | 32 | 1·2334 | 26·09 |
| 99 | 1·8438 | 80·72 | 65 | 1·5390 | 53 00 | 31 | 1·2260 | 25 28 |
| 98 | 1·8415 | 79·90 | 64 | 1·5280 | 52·18 | 30 | 1·2184 | 24·46 |
| 97 | 1·8391 | 79·09 | 63 | 1·5170 | 51·37 | 29 | 1·2108 | 23·65 |
| 96 | 1·8366 | 78·28 | 62 | 1·5066 | 50·55 | 28 | 1·2032 | 22·83 |
| 95 | 1·8340 | 77·46 | 61 | 1·4960 | 49·74 | 27 | 1·1956 | 22·01 |
| 94 | 1·8288 | 76·65 | 60 | 1·4860 | 48·92 | 26 | 1·1876 | 21·20 |
| 93 | 1·8235 | 75·83 | 59 | 1·4760 | 48·11 | 25 | 1·1792 | 20·38 |
| 92 | 1·8181 | 75·02 | 58 | 1·4660 | 47·29 | 24 | 1·1706 | 19·57 |
| 91 | 1·8026 | 74·20 | 57 | 1·4560 | 46·48 | 23 | 1·1626 | 18·75 |
| 90 | 1·8070 | 73·39 | 56 | 1·4460 | 45·66 | 22 | 1·1549 | 17·94 |
| 89 | 1·7986 | 72·57 | 55 | 1·4360 | 44·85 | 21 | 1·1480 | 17·12 |
| 88 | 1·7901 | 71·75 | 54 | 1·4265 | 44·03 | 20 | 1·1410 | 16·31 |
| 87 | 1·7815 | 70·94 | 53 | 1·4170 | 43·22 | 19 | 1·1330 | 15·49 |
| 86 | 1·7728 | 70·12 | 52 | 1·4073 | 42·40 | 18 | 1·1246 | 14·68 |
| 85 | 1·7640 | 69·31 | 51 | 1·3977 | 41·58 | 17 | 1·1165 | 13·86 |
| 84 | 1·7540 | 68·49 | 50 | 1·3884 | 40·77 | 16 | 1·1090 | 13·05 |
| 83 | 1·7425 | 67·68 | 49 | 1·3788 | 39·95 | 15 | 1·1019 | 12·23 |
| 82 | 1·7315 | 66·86 | 48 | 1·3697 | 39·14 | 14 | 1·0953 | 11·41 |
| 81 | 1·7200 | 66·05 | 47 | 1·3612 | 38·32 | 13 | 1·0887 | 10·60 |
| 80 | 1·7080 | 65·23 | 46 | 1·3530 | 37·51 | 12 | 1·0809 | 9·78 |
| 79 | 1·6972 | 64·42 | 45 | 1·3440 | 36·69 | 11 | 1·0743 | 8·97 |
| 78 | 1·6860 | 63·60 | 44 | 1·3345 | 35·88 | 10 | 1·0682 | 8·15 |
| 77 | 1·6744 | 62·78 | 43 | 1·3255 | 35·06 | 9 | 1·0614 | 7·34 |
| 76 | 1·6624 | 61·97 | 42 | 1·3165 | 34·25 | 8 | 1·0544 | 6·22 |
| 75 | 1·6500 | 61·15 | 41 | 1·3080 | 33·43 | 7 | 1·0477 | 5·71 |
| 74 | 1·6415 | 60·34 | 40 | 1·2999 | 32·61 | 6 | 1·0405 | 4·89 |
| 73 | 1·6321 | 59·52 | 39 | 1·2913 | 31·80 | 5 | 1·0336 | 4·08 |
| 72 | 1·6204 | 58·71 | 38 | 1·2826 | 30·98 | 4 | 1·0268 | 3·26 |
| 71 | 1·6090 | 57·89 | 37 | 1·2740 | 30·17 | 3 | 1·0206 | 2·446 |
| 70 | 1·5975 | 57·08 | 36 | 1·2654 | 29·35 | 2 | 1·0140 | 1·63 |
| 69 | 1·5868 | 56·26 | 35 | 1·2572 | 28·54 | 1 | 1·0074 | 0·8154 |
| 68 | 1·5760 | 55·45 | 34 | 1·2490 | 27·72 | | | |
| 67 | 1·5648 | 54·63 | 33 | 1·2409 | 26·91 | | | |

SUMACH (Eng. and Fr.; *Schmack*, Germ.); is the powder of the leaves, peduncles and young branches of the *Rhus coriaria* and *Rhus cotinus*, shrubs which grow in Hungary, the Bannat, and the Illyrian provinces. Both kinds contain tannin, with a little yellow colouring matter, and are a good deal employed for tanning light-coloured leathers; but the first is the best. With mordants, it dyes nearly the same colours as

galls. In calico-printing, sumach affords, with a mordant of tin, a yellow colour; with acetate of iron, weak or strong, a grey or black; and with sulphate of zinc, a brownish-yellow. A decoction of sumach reddens litmus paper strongly; gives white flocks with the proto-muriate of tin; pale-yellow flocks with alum; blue flocks with red sulphate of iron, with an abundant precipitate. In the south of France the twigs and leaves of the *Coriaria myrtilifolia* are used for dyeing, under the name of *rédoul*, or *rodou*.

SUN PAINTING or HELIOGRAPHY. This elegant art having been cultivated with remarkable success by Sir William John Newton, Knt., I have great pleasure in transferring into this Dictionary the very specific instructions which he has published on the subject in the first number of the "Photographic Journal."

To iodize the Paper.—1st. Brush your paper over with muriate of barytes (half an ounce, dissolved in nearly a wine-bottle of distilled water): lay it flat to dry. 2nd. Dissolve sixty grains of nitrate of silver in about an ounce of distilled water. Ditto sixty grains of iodide of potassium in another bottle with the like quantity of water. Mix them together and shake well: let it subside: pour off the water, and then add hot water: shake it well: let it subside: pour off the water, and then add three ounces of distilled water, and afterwards as much iodide of potassium as will redissolve the iodide of silver.

Brush your previously-prepared paper well with this, and let dry; then place them in water, one by one, for about one hour and a half or two hours, constantly agitating the water. As many as a dozen pieces may be put into the water, one after the other, taking care that there are no air bubbles: take them out, and pin to the edge of a board at one corner.

When dry they will be ready for exciting for the camera by the following process:

| | | |
|--|---|--|
| 1. 1 drachm of No. 4., 6 drachms of distilled water. | 2. 20 min. of No. 3., 6 drachms of distilled water. | 3. A saturated solution of gallic acid. |
| 4. 25 grains of nitrate of silver to half an ounce of water. Add 45 min- ims of glacial acetic acid. | 5. 2 drachms of No. 4., 6 drs. of water. | 6. Equal parts of Nos. 1. and 2. N. B.— This must be mixed just before using, and the bottle cleaned afterwards. |

(These are supposed to be in six 1-ounce bottles with glass stoppers.)

To excite for the Camera.— Mix equal parts of Nos. 1. and 2., and with a glass rod excite the iodized paper and blot off; and it may be put in the slide at once, or the number you require may be excited, and put into a blotting-paper book, one between each leaf, and allowed to remain until required to be placed in the slide.

Time of Exposure.— The time varies from three minutes to a quarter of an hour, according to the nature of the subject and the power of the sun; but five minutes is generally the proper time.

To bring out.— Bring out with No. 3., and when the subject begins to appear, add No. 5.; and when sufficiently developed hold it up, and pour water upon it; and then put it into hyposulphite of soda to fix it, for about half an hour or more, and then into water: this is merely to fix it for the after process at your leisure.

To clean the Negative.— Get a zinc tray about three or four inches deep, with another tray to fit in at the top, about one inch deep; fill the lower tray with boiling water, so that the upper tray may touch the water; put your solution of hyposulphite of soda, not strong, in the upper tray, and then your negatives one by one, watching them with care until the iodine is removed; then put them in hot water, containing a small piece of common soda (the size of a nutmeg to about two quarts of water), for about ten minutes; pour off the dirty water, and then add more hot water, shaking them gently for a short time; pour off the water again, and then add fresh hot water, and let it remain until it is cold, after which take them out carefully one by one, and put them in clean cold water for an hour or two; then take them all out together, and hold up to drain for a short time, and then put them between three or four thicknesses of linen, and press as much of the water out as you can; then carefully (for now all the size is removed) lay them out flat separately upon linen to dry.

Mode of Waxing the Negatives.— Melt the pure white wax over a lamp of moderate heat, just merely to keep it in a liquid state; then fill the same deep tray as above described with boiling water, and with another similar to the upper one before described (which must be kept for this purpose only); put a clean piece of blotting-paper in this tray, and lay your negative face downwards, and with a soft flat hog's hair-brush, about an inch wide, dip it into the liquid wax, and brush the negative over, when it will be immediately transparent, and it can be done so that there is very little redundant wax, after which it may be put between two or three thicknesses of blotting-paper and ironed, if necessary, which should not be very hot, when it is ready to take positives from.

Positives on Negative Paper.— Take one part of the iodide of silver before described and add two parts of water; then add as much iodide of potassium as will redissolve it. Brush your paper with the foregoing, let dry, put into water, and proceed, in all respects, as above described for the negatives.

Excite for positives.— Excite with No. 1.: blot off; lay it in your press, place the negative face downwards: expose to the light from ten seconds to half a minute, or more according to the light (not in the sun), and bring out with No. 3.; and when it is nearly developed add No. 1.; then take it up and pour water upon it, and then place it in hyposulphite of soda (cold) until the iodine is removed; after which put it into alum water, about half a teaspoonful of powdered alum in two quarts of water; this will readily remove the hyposulphite, and also fix the positive more particularly; it will also take away any impurities which there may be in the paper, after which put it into clean cold water, and change two or three times.

I have been thus particular in describing the process which I have adopted, more especially for beginners: and with great cleanliness and care in each process, and especially in keeping all the bottles with the chemicals free from dirt of every kind, the foregoing will lead to favourable results.

Motive for washing the paper over with chloride of barium previous to iodizing.— In the first place, I find that it appears to give strength to the paper.

Secondly, that the action in the camera is better and more certain.

Thirdly, it keeps cleaner in the bringing-out process, thereby allowing a longer time for a more complete development.

Fourthly, I have never found any solarizing take place since I have used it (about three years); and, fifthly, I find that it keeps longer and better after it is excited for the camera.

From the observations which I have made since I have made use of chloride of barium, I conclude that it has the effect of destroying any injurious properties which may be in the paper, and more especially with respect to the size; and besides which, when combined with iodide of silver, greater intensity is obtained in the negative.

I have occasionally prepared paper without chloride of barium, but I have always found (except for positives) that I could not rely upon it with the same degree of certainty. I need scarcely add that throughout the whole of this process the greatest care and attention is required, and that the water should be constantly agitated while the paper is in it, and that the water should be once changed.

Rationale of the action of the common soda and powdered alum, &c.— My motive for using common soda to cleanse the negatives is, that it not only removes the hyposulphite of soda more readily, but any impurities which may be in the paper, as well as the whole of the size, such being absolutely necessary for the after waxing process; which, when done, the negative should appear nearly as transparent as glass.

The reason why I prefer alum for the positives is, that while it has the effect of removing the hyposulphite of soda and other impurities in the paper, it does not act upon the size, which in this instance it is desirous to retain.

I have been induced to make a series of experiments, with a view to prevent the fading of the positives, or, indeed, that any portion should be, as it were, eaten away in parts; and since I have adopted the foregoing, in no one instance has any change taken place whatever.—*Sir W. J. Newton.*

Mr. Fenton, one of the most expert and successful heliographers, recommends for paper to be used the same day that it is excited, two grammes of common salt to be added to the iodizing solution. This addition increased the rapidity of the formation of the picture, but much lessened the time during which the paper could be kept in a sensitive state uninjured. The solution for exciting the paper was the usual one of 30 grammes of nitrate of silver and half a drachm of acetic acid to the ounce of water. The paper on which the greater part of Mr. Fenton's negatives were taken was iodized by the following preparation,—

| | | | | |
|-----------------------|---|---|---|---------------|
| Rice water - - - | - | - | - | 1000 grammes. |
| Iodide of potassium - | - | - | - | 30 |
| Bromide of potassium | - | - | - | 3 |
| Cyanide of potassium | - | - | - | 2 |
| Fluoride of potassium | - | - | - | 1½ |

An even film of collodion may be obtained by the following means. Represent the plate of glass by the following figure :—



Hold the plate with the left hand at 1, pour a body of collodion in the centre, tilt towards 1 (being careful not to let it touch the thumb), incline towards 2, run into 3, and pour off at 4. Then hold the plate vertically (resting the corner 4 on the neck of the collodion bottle) to drain; incline it first to the right and then to the left, repeating this several times until the ridges are removed. By these means an even film may be produced without a thick ridge from 2 to 4. The time it may be left without plunging into the silver bath will depend upon the temperature (about half a minute). Dip evenly into the bath, lifting up and down to allow the evaporation of the ether; the film will also saturate more rapidly. When the greasy appearance is gone, it is ready for the camera. Sometimes the film is nearly transparent and bluish, not having sufficient iodide of silver; or it may contain too much iodide, the greater part flaking off in the bath, leaving the collodion with very little, and that patchy; or from being placed in the bath too quick, the lower corner will present a reticulated appearance, which of course renders it useless.

Having exposed the plate the necessary time, the next step is the development. The solution employed by some is prepared with protosulphate of iron. The proportions are,—

| | | | | | |
|----------------------------------|---|---|---|---|----------|
| Water | - | - | - | - | 2 oz. |
| Acetic acid (<i>Beaufoy's</i>) | - | - | - | - | 1 drachm |
| Protosulphate of iron | - | - | - | - | 8 grains |
| Nitric acid | - | - | - | - | 2 drops. |

Mix the water and acetic acid first; then dissolve the sulphate of iron, and, lastly, add the nitric acid, which, by varying the quantity, produces different effects. On pouring the solution over the plate, there is sometimes a difficulty experienced in causing it to flow evenly. Sometimes a little more acetic acid in the developing solution, or, if the plate has been out of the bath for some time, redipping it, will prevent this; but if this does not remove it, and the resulting picture is hard and unpleasant in tone, a new bath is necessary. For positives the resulting picture is more pleasing and delicate, by using the developing agent rather weak. After it has remained on sufficiently long to bring out the image, the undecomposed iodide is to be removed by hyposulphate of soda.

SUSPENSION BRIDGES. Suspension bridges of iron were introduced about the year 1741, at which date one of 70 feet span was thrown over the river Tees. Scamozzi, *Del Idea Archi*, published 1615, conveys some notion of these structures; but Bernouilli first explained their true principles. The Union bridge over the Tweed 449 feet span, constructed by Capt. Sir S. Brown, in 1820, was the first large bar chain bridge erected in Britain. The Newhaven and Brighton suspension piers were also erected by the same engineer. The great bridge by Telford, across the Menai Straits, is 570 feet span; it was commenced in May, 1819, and completed in December, 1825. The Hammersmith bridge, 422 feet span, by Tierney Clark, was completed in 1824. The Montrose bridge, by Rendel, 412 feet span, was erected in 1829; and the Hungerford bridge over the Thames, 676½ feet span, by Brunel, was built in 1844. The *sew-ropes* bridge of Freiburg is 820 feet span. The road-ways of suspension bridges must not merely be *hung* from the chains, but be rendered stiff, to resist the undulatory motion caused by the wind. See Minutes of Proceedings of the Institution of Civil Engineers, Feb. 16, 1841, on this subject.

SWEEP-WASHER, is the person who extracts from the sweeping, potsherds, &c. of refineries of silver and gold, the small residuum of precious metal.

SYNTHESIS, is a Greek word, which signifies combination, and is applied to the chemical action which unites dissimilar bodies into a uniform compound; as sulphuric acid and lime into gypsum; or chlorine and sodium into culinary salt.

SYRUP, is a solution of sugar in water. Cane-juice, concentrated to a density of 1.300, forms a syrup which does not ferment in the transport home from the West Indies, and may be boiled and refined at one step into superior sugar-loaves, with eminent advantage to the planter, the refiner, and the revenue.

Syrup, filtration of, through beds of bone black, has been prescribed as follows by Messrs. Greenwood and Parker. Suppose 5 filter beds, Nos. 1, 2, 3, 4, 5, to be in action,

of which No. 1. has been longest in use; No. 2. the next longest, and so on. As soon as No. 1. has become too impure to be used any longer, it is thrown out of action, No. 2. becomes the first of the series, and No. 5. is brought into use as the last of the series. The process of filtration goes on until No. 2. becomes too impure to be longer employed; it is then thrown out of action, and No. 3. becomes the first in the series; and No. 1. (which has been supplied with fresh filtering materials in the meanwhile), is brought into use as the last of the series. The several filter beds are connected together by pipes (provided with stopcocks), in such a manner that the filtered syrup will pass from the lower part of No. 1. into the upper part of No. 2., and from the lower part of No. 2. into the upper part of No. 3., and so on.

T.

TABBYING, or WATERING, is the process of giving stuffs a wavy appearance with the calender.

TACAMAHAC, is a resin obtained from the *Fagura octandra*, a tree which grows in Mexico and the West Indies. It occurs in yellowish pieces, of a strong smell, and a bitterish aromatic taste. That from the island of Madagascar has a greenish tint.

TAFFETY, is a light silk fabric, with a considerable lustre or gloss.

TAFIA, is a variety of rum.

TALC, is a mineral genus, which is divided into two species, the common and the indurated. The first occurs massive, disseminated in plates, imitative, or crystallized in small six-sided tables. It is splendid, pearly, or semi-metallic, translucent, flexible, but not elastic. It yields to the nail; spec. grav. 2.77. Before the blowpipe, it first whitens, and then fuses into an enamel globule. It consists of—silica, 62; magnesia, 27; alumina, 1.5; oxide of iron, 3.5; water, 6. Klaproth found $2\frac{1}{2}$ per cent. of potash in it. It is found in beds of clay-slate and mica-slate, in Aberdeenshire, Banffshire, Perthshire, Salzburg, the Tyrol, and St. Gothard. It is an ingredient in rouge for the toilette, communicating softness to the skin. It gives the flesh polish to soft alabaster figures, and is also used in porcelain paste.

The second species, or talc-slate, has a greenish-gray colour; is massive, with tabular fragments, translucent on the edges, soft, with a white streak; easily cut or broken, but is not flexible; and has a greasy feel. It occurs in the same localities as the preceding. It is employed in the porcelain and crayon manufactures; as also as a crayon itself, by carpenters, tailors, and glaziers.

TALLOW (*Swif*, Fr.; *Talg*, Germ.); is the concrete fat of quadrupeds and man. That of the ox consists of 76 parts of stearine, and 24 of oleine; that of the sheep contains somewhat more stearine. See **FAT** and **STEARINE**.

Tallow imported into the United Kingdom in 1850, 1,240,645 cwts.; in 1851, 1,223,597 cwts. Retained for home consumption in 1850, 1,219,101 cwts.; in 1851, 1,085,660 cwts. Duty received, 1850, 78,270*l.*; 1851, 68,095*l.*

TALLOW, PINEY. See **PINEY TALLOW**.

TAMPING, is a term used by miners to express the filling up of the hole which they have bored in a rock, for the purpose of blasting it with gunpowder. See **MIXES**.

TAN, or TANNIC ACID. (*Tannin*, Fr.; *Gerbstoff*, Germ.) See its preparation and properties described under **GALLS**.

The barks replete with this principle should be stripped with hatchets and bills from the trunk and branches of trees, not less than 30 years of age, in spring, when their sap flows most freely. Trees are also sometimes barked in autumn, and left standing, whereby they cease to vegetate, and perish ere long; but afford, it is thought, a more compact timber. This operation is, however, too troublesome to be generally practised, and therefore the bark is commonly obtained from felled trees; and it is richer in tannin the older they are. The bark mill is described in Gregory's *Mechanics*, and other similar works.

TANNIN, PREPARATION OF. The substance from which tannin is most frequently obtained is nutgalls, of which it constitutes about 40 per cent. of their weight. It may be procured also from several other sources, such as oak, horse chestnut, sumach, and cinchona barks, catechu, kino, &c. Tannin obtained from these different sources, however, differs materially in some of its characters. The tannin of nutgalls, which is that generally employed for chemical purposes, is sometimes called gallo-tannic acid, to distinguish it from the other species. According to Berzelius, nutgalls yield, besides pure tannin, a small quantity of gallic acid, tannates of potash and of lime, modified tannin in the state which is generally designated by the name *extractive*, and, lastly, a combination of tannin with, probably, pectic acid, which combination is insoluble in cold water, and is met with particularly in the extract of oak bark.

The following TABLE shows the quantity of extractive matter and tan in 100 parts of the several substances : —

| Substances. | In 480, by Davy. | | In 100 parts, by Chaptal & Goussier. | Substances. | In 480, by Davy. | | In 100 parts, by Chaptal & Goussier. |
|--------------------------------|-----------------------------|-----------------------------|--------------------------------------|----------------------------------|-----------------------------|-----------------------------|--------------------------------------|
| | In about 8 oz., by Bignone. | In about 8 oz., by Bignone. | | | In about 8 oz., by Bignone. | In about 8 oz., by Bignone. | |
| White inner bark of old oak | 72 | - | 81 | Bark of cherry-tree | - | 59 | 24 |
| Do. young oak | 77 | - | - | Do. sawlow | - | 59 | - |
| Do. Spanish chestnut | 63 | 30 | - | Do. poplar | - | 76 | - |
| Do. Leicester willow | 79 | - | - | Do. hazel | - | 79 | - |
| Coloured or middle bark of oak | 19 | - | - | Do. ash | - | 82 | - |
| Do. Spanish chestnut | 14 | - | - | Do. trunk of Span. chestnut | - | 104 | - |
| Ditto Leicester willow | 16 | - | - | Do. smooth oak | - | 118 | - |
| Entire bark of oak | 29 | - | - | Do. oak, cut in spring | - | - | - |
| Do. Spanish chestnut | 21 | - | - | Root of tormentil | - | - | 44 |
| Do. Leicester willow | 33 | 109 | - | Cornus sanguinea of Canada | - | - | 36 |
| Do. elm | 13 | 28 | - | Bark of alder | - | - | 32 |
| Do. common willow | 11 | boughs, 31 | - | Do. apricot | - | - | 32 |
| Sicilian sumach | 78 | 138 | - | Do. pomegranate | - | - | 19 |
| Milaga sumach | 79 | - | - | Do. Cornish cherry-tree | - | - | 16 |
| Souchong tea | 48 | - | - | Do. weeping willow | - | - | 14 |
| Green tea | 41 | - | - | Do. Bohemian olive | - | - | 11 |
| Bombay catechu | 261 | - | - | Do. tan shrub with myrtle leaves | - | - | 13 |
| Bengal catechu | 31 | - | - | Do. Virginian sumach | - | - | 10 |
| Nut-galls | 127 | - | 46 | Do. green oak | - | - | 13 |
| Bark of oak, cut in winter | - | 30 | - | Do. service-tree | - | - | 8 |
| Do. beech | - | 41 | - | Do. rose chestnut of Amer. | - | - | 6 |
| Do. elder | - | 58 | - | Do. rose chestnut | - | - | 6 |
| Do. plum-tree | - | 52 | - | Do. rose chestnut of Carolina | - | - | 6 |
| Bark of the trunk of willow | - | 53 | 16 | Do. sumach of Carolina | - | - | 5 |
| Do. sycamore | - | 54 | - | | | | |
| Bark of birch | - | - | - | | | | |

Tannin when in solution attracts oxygen from the atmosphere, and speedily undergoes a change. Gallo-tannic acid is by this means converted into gallic acid, water, and carbonic acid; but it is probable that a change of a different nature takes place with some of the other species of tannin, such as kino.

The following is the method proposed by Berzelius for the purification of tannin with sulphuric acid.

To a hot infusion of nutgalls in water, add a very small quantity of diluted sulphuric acid, and well shake the mixture; a flocculent coagulum will be formed, containing tannin and extractive, and which in separating carries with it any impurities present, in the same manner as in clarifying with white of eggs. Pass the fluid through a filter, and now add sulphuric acid mixed with its own weight of water, in small quantities at a time, until the precipitate, after standing for an hour, is found to form a semi-fluid glutinous mass. As soon as this change is found to have been effected, decant the liquid, and mix with care concentrated sulphuric acid until no further precipitate is formed; a yellowish white mass is thus obtained, which is a combination of sulphuric acid and tannin, and is insoluble in acidulated water. This must be put on a filter; washed with water mixed with a good deal of sulphuric acid; pressed between the filtering paper, and afterwards dissolved in pure water, with which it immediately forms a pale yellow solution. To the solution thus obtained, carbonate of lead in very fine powder is to be added in very small proportions, so as to saturate first the excess of acid, and afterwards, by allowing it to macerate for a short time, that portion of acid combined with the tannin. When the saturation is complete, the colour will become of a more decided yellow. The solution must now be filtered, and evaporated to dryness. The evaporation ought to be conducted *in vacuo*. The hard mass thus obtained will consist of tannin with a portion of extractive formed by the access of the air. This mass being powdered is to be digested with ether, at a temperature of 86° Fahr., until nothing more is taken up by the menstruum; the ether is then allowed to evaporate spontaneously, and the tannin remains in the form of a transparent mass, slightly yellow, which does not change by contact with the air. That which remains undissolved by the ether is a brown extractive, not entirely soluble in water.

Berzelius also gives the following process for the purification of tannin by means of potash.

To a filtered infusion of nutgalls, add a concentrated solution of carbonate of potash, so as to form a white precipitate; but too much potash must not be added, as the precipitate is soluble in excess of the alkali. The precipitate, placed on a filter, is to be washed with ice-cold water, and afterwards dissolved in diluted acetic acid, which sepa-

rates a brown extractive matter, formed by the action of the air during the previous washing. Having filtered the solution, precipitate the tannin by means of acetate of lead, wash the precipitate, and decompose it with hydro-sulphuric acid. The tannin will now form a colourless solution with water, and may be obtained in hard scales on the evaporation of the water *in vacuo* over potassa. Any extractive retained in this tannin may be separated by dissolving it in ether, and allowing the ether to evaporate spontaneously.

A French pharmacien has observed, that sulphuret of mercury has the property of decolorizing tannin, acting in the same way as powdered charcoal does on some substances.

Pelouze's process for the preparation of tannin is much more simple than either of the foregoing; it is also more productive. It consists in treating nutgalls with ether, by the process of percolation. A displacement apparatus of proper size being provided, the galls in fine powder are introduced, so that, when slightly compressed, the apparatus shall be one half filled; sulphuric ether of commerce is now to be added, until the apparatus is full; the top of the apparatus should be partially closed, so as to prevent the evaporation of the ether, while the access of air is admitted. Thus arranged, the apparatus is allowed to remain for 24 hours, by which period there will be found in the receiver two liquids, one floating on the surface of the other. The lighter of these will be perfectly fluid, and but slightly coloured, while that forming the denser stratum will be thick and syrupy, and of a light amber colour. More ether is to be passed through the galls as long as the separation of the percolated liquor takes place. The two fluids are now to be separated by means of a funnel. The heavier fluid, which contains the tannin, is to be repeatedly washed with sulphuric ether, and, being put into a porcelain capsule, is to be submitted to heat in a stove or other suitable apparatus. The vapours of ether and of water will be disengaged; the substance contained in the capsule will be considerably augmented in volume, and a spongy residue will be left, having a brilliant crystalline appearance. This is sometimes colourless, but more frequently of a light yellow colour.

The light fluid which has been separated from the other may be distilled for the recovery of the ether, of which it principally consists.

When, in the above process, the nutgalls are perfectly dry, and pure anhydrous ether is substituted for the ether of commerce, which contains about $\frac{1}{10}$ its weight of water, no tannin is obtained; and when, on the other hand, dry tannin is put into ether which has been distilled from chloride of calcium, only a very small quantity is dissolved, the remainder falling down in the form of powder; although, if the ether of commerce be used, a dense solution will be formed in a few minutes, which will separate to the bottom of the vessel in the same manner as the solution obtained from the galls by displacement.

Pelouze infers from these facts, that of all the constituents of the nutgalls, the tannin is that which has the strongest affinity for water, while it is best soluble in ether; and on this account it separates the water contained in the ether of commerce, together with a small quantity of ether, forming with these the syrupy fluid alluded to. The gallic acid, and some other constituents of the galls, are held in solution by the ether, so that the tannin obtained by this process is very pure.

Pelouze made a great number of attempts to obtain tannin in the crystalline form; but after using various solvents for this purpose, and experimenting with the greatest care, his efforts proved unsuccessful. Examined by the microscope, tannin presents the appearance of a perfectly homogeneous body.

To prepare tannin, take, as in the usual way, equal weights of nut galls and of ether. Expose these two substances in a glass or stoneware vessel to a temperature of 15° or 20° C.; after macerating for one month, the mixture having become a somewhat solid paste, place it in a strong cloth, and submit it to pressure. The product obtained will be of the consistence of molasses, very adhesive to the touch, and does not disengage any portion of the ether which it contains at ordinary temperatures. If, having placed this mixture in an open vessel, we expose it to the sun, or in a stove, at the end of some time we shall perceive the surface to become covered with efflorescence, whilst the rest of the mass maintains the appearance of a thick honey-like fluid for more than six months.

To obviate this inconvenience, which retards the preparation of tannin, and affects its purity, by the deposition of foreign bodies contained in the atmosphere, it is necessary to submit the mixture to the action of an elevated temperature of at least 120° C. This temperature may be obtained in a very fixed manner, by means of a concentrated solution of chloride of calcium. The chloride of calcium thus forms an excellent salt water bath, of very great service in many chemical preparations.

The apparatus most in use is composed, 1st, of an iron boiler, containing the muriate of lime; 2nd, of a flat-bottomed silver basin (one of copper will answer, if well tinned), into which the tannin is to be placed. This latter is to be placed in the muriate of lime, which is to be raised to the boiling temperature. But to obtain a temperature

of 190° C. without burning the product, it is necessary to take some precautions which will readily be foreseen.

Having arranged the apparatus with suitable precautions, and having cautiously set it in operation, the portion of the ether which preserves the tannin in the state of a thick liquid will readily volatilize, and the inferior part of the mass touching the basin will be converted into brilliant, nearly white, very light scales, forming a mass of greater bulk than before. Meanwhile the upper portion remains coloured and transparent, because it contains a larger quantity of the ether, which cannot be driven off, the heat not penetrating with sufficient power to this part. It is in this state that we find the tannin in commerce. But to render it white and light throughout the whole mass, it is proper to cover the basin with a plate of copper, on which some red-hot coals are to be placed; then the phenomenon indicated above will be perceived to take place, namely, the part remaining coloured and transparent will increase in bulk, and become changed into very light white scales, as had happened in the portion touching the basin itself.

TANNING (*Tanner*, Fr.; *Gärberei*, Germ.); is the art of converting skin into **LEATHER**, which see. It has been ascertained, beyond a doubt, that "the saturated infusions of astringent barks contain much less extractive matter, in proportion to their tannin, than the weak infusions; and when skin is quickly tanned (in the former) common experience shows that it produces leather less durable than leather slowly formed."⁶ The older tanners, who prided themselves on producing a substantial article, were so much impressed with the advantages of slowly impregnating skin with astringent matter, that they employed no concentrated infusion (ooze) in their pits, but stratified the skins with abundance of ground bark, and covered them with soft water, knowing that its active principles are very soluble, and that, by being gradually extracted, they would penetrate uniformly the whole of the animal fibres, instead of acting chiefly upon the surface, and making brittle leather, as the strong infusions never fail to do. In fact, 100 pounds of skin, quickly tanned in a strong infusion of bark, produce 187 of leather; while 100 pounds, slowly tanned in a weak infusion, produce only 117½. The additional 19½ pounds weight in the former case serve merely to swell the tanner's bill, while they deteriorate his leather, and cause it to contain much less of the textile animal solid. Leather thus highly charged with tannin is, moreover, so spongy as to allow moisture to pass readily through its pores, to the great discomfort and danger of persons who wear shoes made of it. That the saving of time, and the increase of product, are temptations strong enough to induce many modern tanners to steep their skins in a succession of strong infusions of bark, is sufficiently intelligible; but that any shoemaker should be so ignorant or so foolish as to proclaim that his leather is made by a process so injurious to its quality, is unaccountably stupid.

TANTALUM, is the rare metal, also called **COLUMBIUM**.

TAPESTRY, is an ornamental figured textile fabric of worsted or silk, for lining the walls of apartments; of which the most famous is that of the Gobelins Royal Manufactory, near Paris.

TAPESTRY AND LACE. Some of the objects included in this class in the Exhibition presented, from their remarkable disposition in the building, a highly attractive and interesting appearance, suspended from the girders over the galleries, and thus displayed to the best advantage, and under circumstances the most highly calculated to develop their peculiar beauties;—the specimens of carpets, oil-cloths, and tapestry, must be considered as having occupied a very prominent space in the Exhibition.

The following sub-classes had a place under the general classes, inclusive of these and other articles: A. tapestry, as carpets of all kinds, Axminster, Brussels, Kidderminster, &c., matting, oil-cloth, counterpanes, and ornamental tapestry of different materials; B. lace, as pillow-lace, made wholly by hand, and machine-wrought lace; C. sewed and tamboured muslins; D. embroidery by hand and machinery, and in different materials; E. fringes, tassels, &c.; F. fancy and industrial works.

The manufacture of tapestry, such as carpets, oil-cloths, and lace, is localized in peculiar districts, in a remarkable manner; Kidderminster, Wilton, Glasgow and Halifax, contain extensive factories solely engaged in the production of the various descriptions of carpets in ordinary domestic use. The application of the power-loom to the carpet manufacture is recent, and its use is extending. A great variety of combination of materials was exhibited, many of which indicated a remarkable departure from the ordinary method of manufacturing carpets and similar objects. One of these was a species of mosaic tapestry, where the cut wool was fixed to a ground or foundation of caoutchouc.

The lace productions of Honiton and Buckinghamshire have long attained universal renown. These laces are chiefly wrought by hand at the houses of the persons concerned in their manufacture; but recently a combination of machine-made lace and pillow-made

⁶ Sir H. Davy, on the Operation of Astringent Vegetables in Tanning.—*Phil. Trans.* 1800.

ornament has been introduced, under the title of "appliquée lace." The machine lace of Nottingham has scarcely an inferior degree of celebrity: in that town, factories are in almost constant work, producing by the aid of a large number of the most delicate and costly automatic engines this splendid fabric. In a preceding class these machines were described, and were exhibited in motion in another part of the building. In the south central gallery were some beautiful specimens of the intricate and elegant ornamentation capable of being imparted by these machines. Of the lace made by hand various interesting specimens were shown, which represented much patient effort in the instruction of the poor in this art and considerable taste in design.

Few departments of ornamental industry have experienced so many vicissitudes, in consequence of the introduction of mechanical power, as that of the lace manufacture. The lace of Honiton in Devon has long rivalled the most beautiful and costly productions of the continent. At one period during the last war, veils of Honiton lace sold for very large sums, as much as 100 guineas having been paid for fine specimens: Honiton lace is entirely made on the pillow by hand labour.

The application of machinery to the production of lace is very remarkable and interesting, as probably few introductions of machinery to textile manufactures produced so sudden an alteration on the expiration of the patent protecting it, in the ordinary course of fabrication. The bobbin-net machine was invented in 1809; it came into general use in 1823, and an immense stimulus was communicated to the manufacture. The powers of production of this machine are to hand labour nearly as 30,000 to 5, and the lace production by it has, in plain articles, wholly superseded that made by hand.—See **BOBBINET**.

TAPIOCA, is a modification of starch, partially converted into gum, by heating and stirring cassava upon iron plates. See **CASSAVA** and **STARCH**.

TAR of wood (*Goudron*, Fr.; *Ther*, Germ.); is the viscid, brown-black, resino-oleaginous compound, obtained by distilling wood in close vessels, or in ovens of a peculiar construction. See **CHARCOAL**, **PITCHCOAL**, **COKING OIL**, and **PYROLIGNOUS ACID**. According to Reichenbach, tar contains the peculiar proximate principles, *paraffine*, *eupion*, *creosote*, *picamar*, *pittacall*, besides pyrogenous resin, or *pyretine*, pyrogenous oil, or *pyroleine*, and vinegar. The resin, oil, and vinegar are called *empyreumatic*, in common language.

TAR (COAL). There is not perhaps any waste article of our manufacturing industry which has been so singularly neglected as coal-tar, and yet there can be but very few which offer anything like so fair a field of remuneration for the exercise of skill and ingenuity. To begin: the article has hitherto been, and still in great measure continues, entirely valueless; it has in fact only a nominal price in the market, as is evidenced by the circumstance that it is consumed as fuel at many of our large metropolitan gas works, and at others is sold as low as at the rate of one penny for 5 gallons. This latter is however far from its real value even as fuel, for it has been found in practice that the average heating power of tar, as compared with coke, upon a long series of workings, is as more than two to one, or in other words that a gallon of tar weighing about 10½ lbs. affords as much heat as half a bushel or 22 lbs. of good coke, and this too although the tar contains about one pound of water entangled in its substance or chemically combined, so as not to be separable by long standing. As we have before said, the tar thus adulterated with water is still equal to more than double its weight of good coke as a heating agent, when tested upon a large working scale for many months in succession. This fact ought to convince us, if any doubt yet remains, of the folly and ignorance of those persons who assert that the value of coal as a calorific substance depends solely upon the amount of carbon or coke which it contains, and is in no way proportioned to or affected by the quantity of its tarry or volatile products. The truth would appear to be, that where a coal affords by distillation 30 per cent. of these tarry products, its heating power is exactly double of that which the residuary carbon or coke is able to produce; and this proportion of volatile to fixed matter is just about the ratio existing in most bituminous coals, so that, as a general rule, the advocates of the above hypothesis are wrong to the extent of one half. The high heating power of coal-tar ought to induce the managers of gas works either to use it themselves, or, where this cannot be done, to vend it at a price proportioned to its value in coke; thus, presuming a bushel of coke to be worth 4*d.*, then a gallon of tar as fuel would be worth 2*d.*; whereas, as we have seen, this tar has been sold as low as 5 gallons for one penny, a most convincing proof of the expensive nature of ignorance in some situations. The arrangements now in use at the Equitable Gas Works, Pimlico, are the best we have seen, so far as regards the heating of gas retorts.

The consumption of tar as fuel is, however, after all, but a barbarous misapplication of ingenuity, and far beneath the intelligence of the age. This substance, when properly distilled, is capable of yielding naphtha, a fixed oil, and pitch, the two former of which are vastly more valuable than tar. The relative proportion of these products is, however, very variable, according to the kind and quality of the tar employed. Thus tar from

the condenser is more valuable for its products than the tar of the same coal taken from the hydraulic main, and again cannel coal tar is always superior to common coal-tar. In general we may estimate the available amount of the volatile and fixed matters of coal somewhat in the following order.

| | Naphtha. | Dead oil. | Pitch. |
|---------------------|----------|-----------|--------|
| Common coal tar | 8 | 62 | 35 |
| Ordinary cannel tar | 9 | 60 | 31 |
| Boghead cannel tar | 15 | 67 | 18 |

Of these the naphtha is in large demand for the solution of caoutchouc, the lighting of lamps, and other purposes. The dead oil contains paraffine, and is an excellent lubricator for machinery: the uses of pitch need not be enumerated. At the present time this kind of naphtha reaches about 1s. 6d. per gallon, and the dead oil from 3s. to 9d. per gallon, so that a more profitable form of manufacture can scarcely be desired. The mode of working up these substances from the crude tar is by no means either difficult or expensive. In the first instance the oil is run into a vessel like a common steam boiler, and to which a common condenser or worm is connected; fire is then applied, and the process of distillation carried on till all the naphtha has passed over, which is known by the cessation of the fluid flowing from the worm; after this the heat is raised considerably, and another receiver applied, when a less volatile fluid makes its appearance, which is the dead oil, and which continues to flow until smoke issues from the worm, when the operation is finished by running the pitch out of the boiler, so as to be ready for another operation. The naphtha is now to be mixed with about 10 per cent. by bulk of concentrated sulphuric acid, and when the mixture is cool, peroxide of manganese should be stirred in to the extent of half the weight of the sulphuric acid previously employed, after which the naphtha must be decanted off and re-distilled with care, so as to become colourless, and of a specific gravity of about .850. The dead oil is commonly sent into the market in its crude state, but this is a practice to be condemned. The best way is to treat it in the same manner as the naphtha with sulphuric acid, and peroxide of manganese, after which it should be boiled with a portion of caustic soda lye, and when the oil has risen to the surface by standing, it should be decanted carefully and distilled gradually, first rejecting the watery portions which rise in the beginning of the operation.

When Boghead cannel coal has been used for the production of the tar, the dead oil then obtained contains a portion of paraffine, which crystallizes in the dead oil at temperatures below 50° Fahr. In this state it may be collected by filtration, and purified from adhering oil by pressure, when it may be boiled with about 8 per cent. of its weight of highly concentrated oil of vitriol, which clears and destroys its impurities. The paraffine is next to be boiled in water, and suffered to cool slowly, so as to deposit the charred matters, and this may be repeated once or twice, when it is pure and marketable.

Tar imported into the United Kingdom, in 1850, 12,097 lasts; in 1851, 15,780 lasts.

TARPAULIN (from *Tar*); canvas imbued with tar, used to cover the hatchways of a ship to prevent rain or sea water from entering the hold.

TARRAS. See CEMENT and MORTAR, HYDRAULIC.

TARTAR (*Tartre*, Fr.; *Weinstein*, Germ.); called also argal or argol; is the crude bitartrate of potassa, which exists in the juice of the grape, and is deposited from wines in their fermenting casks, being precipitated in proportion as the alcohol is formed, in consequence of its insolubility in that liquid. There are two sorts of argal known in commerce, the white and the red; the former, which is of a pale-pinkish colour, is the crust let fall by white wines; the latter is a dark-red, from red wines.

The crude tartar is purified, or converted into cream of tartar, at Montpellier, by the following process:—

The argal having been ground under vertical mill-stones, and sifted, one part of it is boiled with 15 of water, in conical copper kettles, tinned on the inside. As soon as it is dissolved, $3\frac{1}{2}$ parts of ground pipe-clay are introduced. The solution being well stirred, and then settled, is drawn off into crystallizing vessels, to cool; the crystals found concreted on the sides and bottom are picked out, washed with water, and dried. The mother-water is employed upon a fresh portion of argal. The crystals of the first crop are re-dissolved, re-crystallized, and exposed upon stretched canvas to the sun and air, to be bleached. The clay serves to abstract the colouring-matter. The crystals formed upon the surface are the whitest, whence the name cream of tartar is derived.

Purified tartar, the bitartrate of potassa, is thus obtained in hard clusters of small colourless crystals, which, examined by a lens, are seen to be transparent 4-sided prisma. It has no smell, but a feebly acid taste; is unchangeable in the air, has a specific gravity of 1.953, dissolves in 16 parts of boiling water, and in 200 parts at 60° F. It is insoluble in alcohol. It consists of 24.956 potassa, 70.276 tartaric acid, and 4.768 water. It

affords, by dry distillation, pyrotartaric acid, and an empyreumatic oil; while carbonate of potassa remains associated with much charcoal in the retort, constituting black flux. Tartar is used in dyeing, medicine, and for extracting.

TARTARIC ACID. (*Acide tartrique*, Fr.; *Weinsteinsäure*, Germ.) This is prepared by adding gradually to a boiling-hot solution of 100 parts of tartar, in a large copper boiler, 26 of chalk, made into a smooth pap with water. A brisk effervescence ensues, by the disengagement of the carbonic acid of the chalk, while its base combines with the acid excess in the tartar, and forms an insoluble precipitate of tartrate of lime. The supernatant liquor, which is a solution of neutral tartrate of potassa, must be drawn off by a siphon, and decomposed by a solution of chloride of calcium (muriate of lime). 28½ parts of the dry chloride are sufficient for 100 of tartar. The tartrate of lime, from both processes, is to be washed with water, drained, and then subjected, in a leaden cistern, to the action of 49 parts of sulphuric acid, previously diluted with 8 times its weight of water; 100 of dry tartrate take 75 of oil of vitriol. This mixture, after digestion for a few days, is converted into sulphate of lime and tartaric acid. The latter is to be separated from the former by decantation, filtration through canvas, andedulcoration of the sulphate of lime upon the filter.

The clear acid is to be concentrated in leaden pans, by a moderate heat, till it acquires the density of 40° B. (spea. grav. 1·38), and then it is run off, clear from any sediment, into leaden or stoneware vessels, which are set in a dry stove-room for it to crystallize. The crystals, being re-dissolved and re-crystallized, become colourless 6-sided prisma. In decomposing the tartrate of lime, a very slight excess of sulphuric acid must be employed; because pure tartaric acid would dissolve any tartrate of lime that may escape decomposition. Bone black, previously freed from its carbonate and phosphate of lime, by muriatic acid, is sometimes employed to bleach the coloured solutions of the first crystals. Tartaric acid contains nearly 9 per cent. of combined water. It is soluble in two parts of water at 60°, and in its own weight of boiling water. In its dry state, as it exists in the tartrate of lime or lead, it consists of 36·8 of carbon, 3 of hydrogen, and 60·2 of oxygen. It is much employed in calico-printing, and for making sodaic powders.

In consequence of the great variation in the constituents of argol or rough tartar, the manufacture of tartaric acid is not nearly so simple as a first glance at its several processes might lead an inexperienced individual to suppose. The theory of preparing tartaric acid seems, indeed, a remarkably easy affair; and, provided the materials operated upon were pure or of uniform quality, no kind of manufacture could put on less the appearance of risk or speculation. But too many know, to their cost, with what ready facility the whole profit, and something more, of a large operation, will occasionally ooze off through a variety of unknown channels, and present a sadly defective and truncated return of saleable produce. In fact, money is not unfrequently lost in this manufacture by very old and experienced makers. The differences in argol arise from the greater or smaller amount of tartrate of lime combined with the bitartrate of potash; these differences will, in a commercial way, amount to from 5 to 25 or even 30 per cent; and herein resides a difficulty, requiring more analytical skill and chemical knowledge than is commonly found amongst practical manufacturers. We will suppose that an argol has been purchased, containing by analysis 70 per cent. of bitartrate of potash, but also, though unknown to the purchaser, containing 20 per cent. of tartrate of lime. According to the process followed, this argol would be dosed with a definite proportion of chalk or carbonate of lime, so as to produce tartrate of lime with the extra tartaric acid of the super-tartrate of potash. This tartrate of lime, being insoluble, would fall and mingle with the 20 per cent. already existing; but as in practice the quantity of sulphuric acid employed for subsequent decomposition of this tartrate of lime is proportioned to the amount of chalk originally employed, it follows that the tartrate of lime naturally present in the argol is left undecomposed, and comes to be regarded as sulphate of lime, to the great loss of the manufacturer, who probably finds his more intelligent neighbour able to buy as he buys, and yet capable of underselling him in the open market. To illustrate the full bearing of this and other interesting points in the fabrication of tartaric acid, it will be better to enter into a condensed description of the whole process, taken on the assumption that pure bitartrate of potash is the raw material to be used in the manufacture. Having weighed out a given proportion of this substance, it is to be thrown into a leaden boiler, provided with a stirring apparatus, and the whole has sometimes a closely fitting cover provided with a pipe for carrying off and utilizing the carbonic acid gas generated, as we shall see, during the first operation. The bitartrate of potash having been introduced into this vessel, water is then added, and a quantity of dried chalk, in the ratio of about one part of dry chalk to four of bitartrate of potash, put in by degrees. After boiling and stirring for some time, the effervescence due to the carbonic acid, arising from the decomposition of the chalk, ceases; and then the tartrate of lime is to be allowed to subside, that the clear solution of tartrate of potash may be tested with litmus, to demonstrate the non-existence of bitartrate of potash in

the fluid. This being satisfactory, a quantity of finely powdered sulphate of lime is now thrown in, equal to one and three quarter times the weight of the dried chalk first employed, or rather better than $\frac{1}{3}$ ths of the bitartrate of potash. This mixture must be boiled for a considerable time, and assiduously stirred until a little of the clear liquor, when hot, affords no precipitate on the addition of a strong solution of nitrate of lime. The decomposition is now complete, and the whole of the tartaric acid will be found united to the lime as an insoluble powder (tartrate of lime); whilst the potash, in the state of sulphate, exists in solution, and may be procured by evaporating the clear liquor. After the insoluble tartrate of lime has been two or three times washed with warm water, it is to be decomposed by a slight excess of diluted sulphuric acid, made by mixing together oil of vitriol, equal to 2½ times the weight of the chalk used, with 10 times its bulk of water. In this way sulphate of lime is formed, which is set aside for a subsequent operation, leaving the tartaric acid with a trifling excess of sulphuric acid in the clear solution. This solution, when crude tartar has been employed, has generally a brown or reddish-yellow colour, and requires to be digested for some hours upon animal charcoal, to purify and bleach it. When this is effected, it is carefully evaporated on a water bath, or by steam heat, and, after proper concentration, run out into large cylindrical leaden coolers to crystallize. A second solution, digestion on animal charcoal, and recrystallization, are generally needed to render the acid white enough for the market. From the above, it will be seen that unless the manufacturer is not only aware of the surplus tartrate of lime present in the rough tartar he buys, but has also a tolerably correct idea of its quantity, he runs a risk, almost amounting to a certainty, of leaving undecomposed tartrate of lime in his sulphate of lime; and as this latter is in great part a waste product, the two pass away from the works under one name, as mere refuse. But there is also an important consideration connected with the evaporation of solutions of tartaric acid. This is generally, and indeed we might say invariably, done in contact with atmospheric air, the solution meanwhile containing a perceptible excess of sulphuric acid; but, under such treatment, tartaric acid undergoes decomposition almost as readily as sugar; and therefore, like sugar, it ought to be operated upon *in vacuo*, or, at least, in a vessel similar to a vacuum pan, but lined with lead, to prevent cupreous contamination. In this way, and by knowing the exact composition of the rough tartar used in every instance, the greatest certainty might ultimately be secured in this delicate manufacture, instead of the conflicting and paradoxical results which now annoy, and too frequently dishearten, the practical operator.

TARTRATES, are salts composed of tartaric acid, and oxidized bases, in equivalent proportions.

TAWING, is the process of preparing the white skins of the sheep doe, &c. See LEATHER.

TEA. This well-known plant has recently acquired peculiar interest among men of science, both in a chemical and physiological point of view. In its composition it approaches, by the quantity of azote it contains, to animalized matter, and it seems thereby qualified, according to Liebig, to exercise an extraordinary action on some of the functions of animals, especially the secretion of bile. The chemical principle characteristic of tea, coffee, and cocoa beans, is one and the same when equally purified, from whichever of these substances it is extracted; and is called indifferently either Theine or Caffeine. Mulder takes it from tea, by treating the evaporated extract by hot water, with calcined magnesia, filtering the mixture, evaporating to dryness the liquor which passes through, and digesting the residuum in ether. This solution being distilled, the ether passes over, and the theine remains in the retort. This principle is extracted in the same way from ground round raw coffee and from *guarana*, a preparation of the seeds of *Pavlovnia*, highly valued by the Brazilians. Theine, when pure, crystallizes in fine glossy needles, like white silk, which lose, at the heat of boiling water, 8 per cent. of their weight, constituting its two atoms of water of crystallization. These needles are bitter tasted. They melt at 350° F., and sublime at 543° without decomposing. The crystals dried at 350° dissolve in 98 parts of cold water, 97 of alcohol, and 194 parts of ether. In their ordinary state, they are but little more soluble in these menstrua. Theine is a feeble base, and is precipitable by tannin alone from its solutions.

Dr. Stenhouse prepares theine by precipitating a decoction of tea with solution of acetate of lead, evaporating the filtered liquor to a dry extract, and exposing this extract to a subliming heat in a shallow iron pan, whose mouth is covered flatly with porous paper luted round the edges, as a filter to the vapour, and surmounted with a cap of compact paper, as a receiver to the crystals. In this way he obtained, at a maximum, only 1·37 from 100·00 of tea. But M. Peligot, from the quantity of azote amounting to about 6 per cent., which he found in the tea leaves, being led to believe that much more theine existed in them than had hitherto been obtained, adopted the following improved process of extraction. To the hot infusion of tea, subacetate

of lead and then ammonia were added; through the filtered liquor a current of sulphuretted hydrogen was passed to throw down all the lead, and the clear liquid being evaporated at a gentle heat afforded, on cooling, an abundant crop of crystals. By re-evaporation of the mother liquor, more crystals were procured, amounting altogether to from 5 to 6 out of 100 of tea.

The composition of theine may be represented by the chemical formula, C^8, H^8, N^2, O^2 ; whence it appears to contain no less than 29 per cent. of nitrogen or azote.

Peliget found, on an average, in 100 parts of—

| | Parts soluble in boiling Water. |
|---------------------|---------------------------------|
| Dried black teas | 43·2 |
| — green teas | 47·1 |
| Black teas, as sold | 38·4 |
| Green teas, ditto | 43·4 |

Tea, by Mulder's general analysis, has a very complex constitution; 100 parts contain—

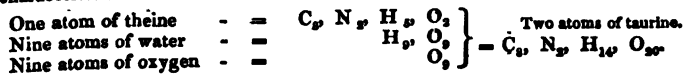
| | Green. | Black. |
|---|--------|--------|
| Essential oil (to which the flavour is due) | 0·79 | 0·60 |
| Chlorophyle (leaf-green matter) | 2·22 | 1·84 |
| Wax | 0·28 | |
| Resin | 2·22 | 3·64 |
| Gum | 8·56 | 7·28 |
| Tannin | 17·80 | 12·88 |
| Theine | 0·43* | 0·46 |
| Extractive matter | 22·80 | 19·88 |
| Do., dark-coloured | — | 1·48 |
| Colorable matter separable by muriatic acid | 23·60 | 19·12 |
| Albumen | 3·00 | 2·80 |
| Vegetable fibre | 17·08 | 28·32 |
| Ashes | 5·56 | 5·24 |

Since the proportion of azote in theine and caffeine is so much greater than even in any animal compound, urea and uric acid excepted, and since so many different nations have been, as it were, instinctively led to the extensive use of tea, coffee, and chocolate or cocoa, as articles of food and enlivening beverage, which agree in no feature or property, but in the possession of one peculiar chemical principle, we must conclude that the constitution of these vegetable products is no random freak of nature, but that it has been ordained by Divine Wisdom for performing beneficial effects on the human race. Hitherto, indeed, medicine, a conjectural art, exercised too much by men superficially skilled in the science of nature, and the slaves or abettors of baseless hypotheses, has laid tea and coffee generally under its ban, equally infallible with the multitude, as that of the Pope in the olden time, and has denounced their use, as causing a variety of nervous and other *nosological* maladies. But chemistry, advancing with her unquenchable torch into the darkest domains of Nature, has now unveiled the mystery, and displayed those elemental transformations of the organic functions in the human body, to which tea and coffee contribute a salutary and powerful aid.

Liebig, in his admirable researches into the kingdoms of life, has been led to infer that the bile is one of the products resulting from the decomposition of the animal tissues, and that our animal food may be resolved by the action of oxygen, so amply applied to the lungs in respiration, into bile and urea, the characteristic constituent of urine.

When the consumption of tissue in man is small, as among mankind in the artificial state of life, with little exercise and consequently languid digestion, assimilation, and decomposition, the constant use of substances rich in azotized compounds, closely analogous to the chief principle of the bile, must assist powerfully in the production of this secretion, so essential to the healthy action of the bowels and other organs. Liebig has fully proved that the bile is not an excrementitious fluid, merely to be rejected, as a prejudicial inmate of the system, but that it serves, after secretion, some important purpose in the animal economy, being, in particular, subservient to respiration.

I shall conclude these remarks, perhaps more appropriate to a work on chemistry than to the present, by stating the relation between *theine* and the animal product *taurine*, the characteristic constituent of bile.



* This constituent is obviously much underrated.

The letters C, N, H, O, denote carbon, nitrogen or azote, hydrogen, and oxygen; and the figures attached to each, the number of atoms; one atom of carbon being 6, one of azote 14, one of hydrogen 1, and one of oxygen 8; from which the composition of the bodies, theine and taurine, may be easily computed for 100 parts. Now, supposing one tenth of the bile to consist of solid matter, and this solid matter to be choleric acid (resolvable into taurine but different from it), which contains 3.87 of nitrogen, then 2.8 grains of theine would afford to 480 grains of bile (supposed solid, or 4,800 grains in its ordinary state) all the nitrogen required for the constitution of *taurine*, its peculiar crystalline principle.

The quantity of tea grown and consumed in China cannot be ascertained, but the consumption of Europe and America may be taken as follows:—

| | | | |
|--------------------------|---|---|----------------|
| Russia | - | - | 6,500,000 lbs. |
| United States of America | - | - | 8,000,000 |
| France | - | - | 2,000,000 |
| Holland | - | - | 2,800,000 |
| Other countries | - | - | 2,000,000 |
| Great Britain | - | - | 50,000,000 |

71,300,000 lbs. or 31,850 tons.

The number of tea-dealers in the year 1839 was, in England, 82,794; in Scotland, 13,611; and in Ireland, 12,744; making a total of 109,179. It is presumed that in consequence of the increased population their number at present must exceed 120,000.

The observations of Liebig afford a satisfactory explanation of the cause of the great partiality of the poor, not only for tea, but for tea of an expensive and superior kind. He says, "We shall never certainly be able to discover how men were first led to the use of the hot infusion of the leaves of a certain shrub (tea), or of a decoction of certain roasted seeds (coffee). Some cause there must be, which will explain how the practice has become a necessary of life to all nations. But it is still more remarkable, that the beneficial effects of both plants on the health must be ascribed to one and the same substance (*théine* or *cafféine*), the presence of which in two vegetables, belonging to natural families, the products of different quarters of the globe, could hardly have presented itself to the boldest imagination. Yet recent researches have shown, in such a manner as to exclude all doubt, that *théine* and *cafféine* are in all respects identical." And he adds, "That we may consider these vegetable compounds, so remarkable for their action on the brain, and the substance of the organs of motion, as elements of food for organs as yet unknown, which are destined to convert the blood into nervous substance, and thus recruit the energy of the moving and thinking faculties." Such a discovery gives great importance to tea and coffee, in a physiological and medical point of view.

At a meeting of the Academy of Sciences, in Paris, lately held, M. Peligot read a paper on the Chemical Combinations of Tea. He stated, that tea contained essential principles of nutrition, far exceeding in importance its stimulating properties: and showed that tea is, in every respect, one of the most desirable articles of general use. One of his experiments on the nutritious qualities of tea, as compared with those of soup, was decidedly in favour of the former.

Coffee is grown in Brazil, Cuba, Hayti, Java, British West Indies, Dutch Guiana, States of South America, French West India Colonies, Porto Rico, Sumatra, Ceylon, Bourbon, Manilla and Mocha. Brazil produces the largest quantity, 72,000,000 pounds weight; and the other states and colonies according to the order in which they are enumerated, down to Mocha, which produces the least, or 1,000,000 pounds; making a total of 246,000,000 pounds, equal to the consumption of the enormous quantity of 2,900 tons weekly, or 150,800 tons per annum.

From the official returns, the quantities of coffee exported in one year from the different places of production were 154,550 tons:

| | tons. | | tons. |
|-------------------|-------|------------------------------------|---------|
| To France | - | Denmark | - |
| U. S. of America | - | Spain | - |
| Trieste | - | Prussia | - |
| Hamburg | - | Naples and Sicily | - |
| Antwerp | - | Venice | - |
| Amsterdam | - | Fiume | - |
| Bremen | - | Great Britain (average of 10 yrs.) | 18,250 |
| St. Petersburg | - | | |
| Norway and Sweden | - | | 154,550 |

Every reflecting man will admit that articles of such vast consumption as tea and

coffee (amounting together to more than 185,000 tons annually), forming the chief liquid food of a whole nation, must exercise a great influence upon the health of the people, and that any discovery which tends to the purification of these alimentary drinks, rendering them more wholesome, without rendering them less agreeable, is a great boon conferred upon society.

TEA, COMPOSITION OF. The most remarkable products that have been indicated in tea are, — 1st, tannin; 2nd, an essential oil, to which it owes its aroma, and which has great influence on its commercial value; 3rd, a crystalline substance, very rich in nitrogen, *theine*, which is also met with in coffee (whence it is frequently termed *caffeine*), and which is likewise found in Guarana a remedy highly valued by the Brazilians.

Besides these three, M. Mulder extracted from tea eleven other substances, which are usually met with in all leaves. The same chemist found, in the various kinds of tea from China and Java, a little less than a half per cent. of their weight of theine. Dr. Stenhouse, in a recent investigation, obtained from 1.37 to 0.98 theine from 100 parts of tea.

An accurate knowledge of the amount of the nitrogenous principles contained in tea being of the utmost importance, he first determined the total amount of nitrogen contained in the leaf, in order thus to have a safe guide when subsequently isolating the substances between which this nitrogen is distributed.

On determining the nitrogen by M. Dumas's process, he obtained the following numbers: —

| | Nitrogen in 100 parts, tea dried at 230°. | | | | |
|---------------|--|---|---|---|------|
| Pekoe tea | - | - | - | - | 6.58 |
| Gunpowder tea | - | - | - | - | 6.15 |
| Souchong tea | - | - | - | - | 6.15 |
| Assam tea | - | - | - | - | 5.10 |

This amount of nitrogen is far more considerable than has been detected in any vegetable hitherto analysed. These first experiments prove, therefore, the existence of from 20 to 30 per cent. of nitrogenous substances in tea, while former analyses scarcely carry the proportion to more than three or four hundredths. He sought for these substances successively in the products of the leaf soluble in boiling water, in those which do not dissolve in water, and in each of the substances which might be separated either from the infusion or from the exhausted leaf.

He first determined the proportion of soluble products which boiling water extracts from tea, and operated upon 27 kinds of tea, taking into consideration the water already contained in the leaf, either from its desiccation in China not having been complete, or from having absorbed during or after its transport a certain quantity of atmospheric water. He found that the green teas contain, on an average, 10, the black teas 8 per cent. of water.

The proportion of products soluble in hot water varies considerably, and depends chiefly upon the age of the leaf, which is younger, and consequently less liqueous, in the green than in the black tea. On an average he found in 100 parts of

| | Parts soluble in boiling water. | | | | |
|--------------------------------------|------------------------------------|----|---|---|--------|
| Dry black teas | - | - | - | - | - 43.2 |
| Dry green teas | - | - | - | - | - 47.1 |
| Black teas in their commercial state | - | - | - | - | - 38.4 |
| Green teas | do | do | - | - | - 43.4 |

When an infusion of tea is evaporated to dryness, a chocolate brown residue remains, which, when derived from green gunpowder, contains 4.35 per cent. nitrogen; if from black souchong, 4.70 per cent. nitrogen.

These considerable quantities of nitrogen, do they belong to several principles contained in the infusion, or solely to the theine, which is the only nitrogenous substance hitherto noticed in it? He first endeavoured to solve this question: as the quantitative determination of theine is a difficult operation from its being soluble in water, alcohol, and ether, and not being precipitated by any reagent with the exception of tannin, he first ascertained whether the other substances which might be separated from the infusion contained any nitrogen.

The subacetate of lead throws down about half the soluble constituents contained in this infusion. The precipitate, which is of a more or less dark yellow, according to whether it is derived from green or black tea, contains the whole of the colouring matter, the whole of the tannin, and a peculiar acid, which affords an insoluble salt of a light yellow colour with the subacetate of lead. He has not yet terminated the examination of this acid.

I found this mixed precipitate to contain very little nitrogen; it is therefore in the

portion of the infusion which is not precipitated that the substances containing this element must be sought for.

To determine the amount of theine, M. Mulder evaporates the infusion with caustic magnesia, and treats the residue with ether, which only dissolves out the theine. On modifying this process Dr. Stenhouse has obtained the following quantities of theine from 100 parts of

| | | | | | | |
|---|---|---|---|---|---|------|
| Hyson - | - | - | - | - | - | 2.40 |
| Another kind | - | - | - | - | - | 2.56 |
| Mixture in equal parts of gunpowder, hyson, imperial, caper and pekoe | - | - | - | - | - | 2.70 |
| Gunpowder | - | - | - | - | - | 4.1 |
| Another kind | - | - | - | - | - | 3.5 |

These quantities are far more considerable than have been obtained either by M. Mulder or Dr. Stenhouse; but, at the same time, they do not account for the total amount of nitrogen of the infusion in the state of theine, for the composition of theine being represented by the formula $C^8 H^8 N^2 O^2$, and this substance containing 29.0 per cent. of nitrogen, gunpowder tea should contain 7.4 and souchong 6.5 theine in 100 parts of these teas taken in their ordinary state, if no other nitrogenous substance accompanied the theine in the solution.

By the following very simple process, I succeeded in obtaining a proportion of theine far more considerable than I first found. To the hot infusion of tea subacetate of lead and then ammonia are added; the liquid is separated by filtration from the precipitate, and a current of sulphuretted hydrogen passed through it, the sulphuret of lead is removed from the solution, which is evaporated at a gentle heat; on cooling, an abundant crop of crystals of theine is obtained, and the mother lye affords more crystals on cautious evaporation. The first crystals are purified by recrystallization from water, and then the mother lye is used to dissolve the second crop, so as to have the least possible quantity of mother lye and the largest amount of crystals. In this manner I obtained from 50 grammes of gunpowder tea 1.92 grammes of crystallized theine, which is equal to 3.84 per cent.

But there remains a syrupy liquid which still contains some theine. This I determined by means of a solution of tannin of known strength, which precipitates it alone, and I believe entirely, if the liquid be cold and accurately neutralized with ammonia as the tannin is added.

On adding the fresh quantity of theine, isolated by this re-agent to that obtained as crystals, one hundred parts of gunpowder tea, taken in its ordinary state, furnished 5.84 theine; 100 parts of the same tea in its dry state gave 6.22 of this substance.

These numbers approach very nearly to those which should be obtained if theine were the only nitrogenous substance contained in the infusion. There is, however, still a deficit of 0.75 nitrogen, but it must be remembered that I obtained only a minimum. It is, moreover, possible that the infusion contained some ammoniacal salts, or that a small portion of the theine was decomposed during the evaporation of the liquid: this substance being very liable to alteration, like the compounds rich in nitrogen, which it resembles by its composition and properties.

However this be, it may be concluded from the above experiments, 1., that theine is the principal nitrogenous substance contained in the infusion of tea, 2., that it exists in larger quantity than has hitherto been admitted.

The portion of tea from which boiling water extracted no more soluble principle contained in 100 parts, dried 230°, 4.46 nitrogen for the souchong, and 4.90 for the gunpowder. These quantities, added to those of the infusion, represent very nearly the nitrogen ascertained by analysis to exist in the entire leaf.

On boiling for some time the exhausted leaves in water containing $\frac{1}{10}$ of their weight of potash, a brown liquid is obtained, which affords, on the addition of dilute sulphuric or acetic acid, a considerable flocculent and brown precipitate, which contains 8.45 per cent. nitrogen; the product of another preparation gave 9.93. Alcohol and ether remove from this precipitate about 90 per cent. of a green substance, which appears to contain a fat acid. This product is not pure after this treatment, for it is strongly coloured and contains pectic acid; nevertheless that which contained 8.45 nitrogen afforded 11.35 of this element after being treated with alcohol and ether. Although I have not obtained this substance in a state of purity, I do not hesitate to consider it, from the general resemblance of its characters, as identical with the caseine from milk.

It is probable that this body exists in the insoluble portion of the leaf in combination with tannin, and that the potash acts by destroying this combination. The presence of this substance in tea is a fact the more worthy of attention as it occurs to a very large amount, if, as is probable, the greater portion of the nitrogen in the exhausted leaf is

derived from it. On admitting, with MM. Dumas and Cahours, 16 per cent. of nitrogen in caseine, the exhausted leaves would contain no less than 28 hundredths of this principle; tea in its ordinary state would contain from 14 to 15 per cent.

I found it impossible to separate the whole of this caseine from the tea. I obtained, in one experiment, from 100 parts of exhausted leaves, 35 of the mixture above mentioned, containing from 8 to 10 per cent. nitrogen, which represent from 18 to 20 per cent. of caseine supposed pure; but the leaves, after being treated twice with potash, still contained 2.73 per cent. This nitrogen, in the state of caseine, would represent 5.7 per cent., so that we thus approach very close to the amount of the nitrogen indicated by analysis.

It will be seen from these experiments, that tea contains a proportion of nitrogen altogether exceptional; it must, however, be remembered that the leaf is not taken in its natural state, but that it comes to us after having been manufactured. It is well known that, before being delivered into commerce, tea is submitted to a torrefaction, which softens the leaf and allows of a rather considerable quantity of an acrid and slightly corrosive juice being expressed by means of the pressure of the hands; the leaf is then rolled up, and dried more or less rapidly according to whether green or black tea is to be made from it. Now it is possible that this juice contains little or no nitrogen, and that consequently its separation would increase the amount of nitrogen which remains in the leaf. On determining the quantity contained in fresh leaves from some tea plant cultivated in gardens near Paris, I found 4.37 nitrogen, in 100 parts of the dried tea. Perhaps the difference of climate and mode of culture may suffice to produce these variations.

I will conclude this paper by some observations on the use of tea considered as beverage and as aliment. It cannot be denied, considering the amount of nitrogen contained in this leaf and the presence of caseine, that tea is a true aliment when consumed as a whole, with or without previous infusion, as, according to information, some of the Indian tribes do.

We find the following statement in one of Victor Jacquemont's letters: "Tea comes to Cashmere by caravans, through Chinese Tartary and Thibet. . . . It is prepared with milk, butter and salt, and an alkaline salt of a bitter taste. At Kurnoor it is prepared in a different manner: the leaves are boiled for an hour or two, the water is thrown away, and the leaves mixed with rank butter, &c." Is it not evident that in the first case the instinctive use of the alkaline salt has for its object the solution of the caseine, and thus causing it to form part of the infusion, while in the second the caseine remains, and is consumed with the leaf itself.

But it is not in this manner that tea is prepared among the more civilized nations. Ought we to admit that its infusion, made with little and much water, has any other actions but on the nervous system, by producing an excitement which may for a certain time form a substitute for veritable food? Can it be compared to other substances of undoubted efficacy as nutriment, to milk or to meat broth? Without seeking to solve these difficult questions, I have determined some of the elements which must occupy an important rank in their discussions. I have determined the weight and the nature of the principles which enter into the infusion of tea, as it is usually prepared for drinking. The tea is not then deprived of all its soluble principles; the leaf still retains at least a third of what it abandons to water when submitted to frequent washings, an infusion, for instance, made with 20 grains of gunpowder tea and one quart of water afforded 6.33 grains of soluble products, containing very nearly one grain of theine. — *Peligoz, in Comptes Rendus, July 17. 1843.*

TEA, *green*, contains 34.6 parts of tannin, 5.9 of gum, 5.7 of vegetable albumine, 51.3 of ligneous fibre, with 2.5 of loss; and *black* tea contains 40.6 of tannin, 6.3 of gum, 5.4 of vegetable albumine, 44.8 of ligneous fibre, with 2 of loss. The ashes contain silica, carbonate of lime, magnesia, and chloride of potassium. — *Frank. Davy* obtained 32.5 of extract from Souchong tea; of which 10 were precipitated by gelatine. He found 8.5 only of tannin in green tea. The latter chemist is most to be depended upon. Chemical analysis has not yet discovered that principle in tea to which its exciting property is due.

Preparation of green tea. It is brought to Canton unprepared; as Bohea, *Saushung*, and is thrown into a hemispherical iron pan, kept red-hot over a fire. The leaves are constantly stirred till they are thoroughly heated, when they are dyed, by adding for each pound of tea, 1 spoonful of gypsum, 1 of turmeric, and 2 or 3 of Prussian blue. The leaves instantly change into a bluish green, and after being well stirred for a few minutes, are taken out, being shrivelled by the heat. They are now sifted; the small longish leaves fall through the first sieve, and form young Hyson; the roundest granular ones fall through the last, and constitute Gunpowder, or Choo-chia.

*The Chinese method of making Black Tea in Upper Assam.**—In the first place, the

* By C. A. Bruce, superintendent of tea culture.

youngest and most tender leaves are gathered ; but when there are many hands and a great quantity of leaves to be collected, the people employed nip off with the forefinger and thumb the fine end of the branch with about four leaves on, and sometimes even more, if they look tender. These are all brought to the place where they are to be converted into tea ; they are then put into a large, circular, open-worked bamboo basket, having a rim all round, two fingers broad. The leaves are thinly scattered in these baskets, and then placed in a framework of bamboo, in all appearance like the side of an Indian hut without grass, resting on posts, 2 feet from the ground, with an angle of about 25°. The baskets with leaves are put in this frame to dry in the sun, and are pushed up and brought down by a long bamboo with a circular piece of wood at the end. The leaves are permitted to dry about two hours, being occasionally turned ; but the time required for this process depends on the heat of the sun. When they begin to have a slightly withered appearance, they are taken down and brought into the house, where they are placed on a frame to cool for half an hour. They are then put into smaller baskets of the same kind as the former, and placed on a stand. People are now employed to soften the leaves still more, by gently clapping them between their hands, with their fingers and thumb extended, and tossing them up and letting them fall, for about five or ten minutes. They are then again put on the frame during half an hour, and brought down and clapped with the hands as before. This is done three successive times, until the leaves become to the touch like soft leather ; the beating and putting away being said to give the tea the black colour and bitter flavour. After this the tea is put into hot east-iron pans, which are fixed in a circular mud fireplace, so that the flame cannot ascend round the pan to incommode the operator. This pan is well heated by a straw or bamboo fire to a certain degree. About two pounds of the leaves are then put into each hot pan, and spread in such a manner that all the leaves may get the same degree of heat. They are every now and then briskly turned with the naked hand, to prevent a leaf from being burnt. When the leaves become inconveniently hot to the hand, they are quickly taken out and delivered to another man with a close-worked bamboo basket ready to receive them. A few leaves that may have been left behind are snarply brushed out with a bamboo broom ; all this time a brisk fire is kept up under the pan. After the pan has been used in this manner three or four times, a bucket of cold water is thrown in, and a soft brickbat and bamboo broom used, to give it a good scouring out ; the water is thrown out of the pan by the brush on one side, the pan itself being never taken off. The leaves, all hot of the bamboo basket, are laid on a table that has a narrow rim on its back, to prevent these baskets from slipping off when pushed against it. The two pounds of hot leaves are now divided into two or three parcels, and distributed to as many men, who stand up to the table with the leaves right before them, and each placing his legs close together ; the leaves are next collected into a ball, which he gently grasps in his left hand, with the thumb extended, the fingers close together, and the hand resting on the little finger. The right hand must be extended in the same manner as the left, but with the palm turned downwards, resting on the top of the ball of tea leaves. Both hands are now employed to roll and propel the ball along : the left hand pushing it on, and allowing it to revolve as it moves ; the right hand also pushes it forward, resting on it with some force, and keeping it down to express the juice which the leaves contain. The art lies here in giving the ball a circular motion, and permitting it to turn under and in the hand two or three whole revolutions, before the arms are extended to their full length, and drawing the ball of leaves quickly back without leaving a leaf behind, being rolled for about five minutes in this way. The ball of tea leaves is from time to time gently and delicately opened with the fingers, lifted as high as the face, and then allowed to fall again. This is done two or three times, to separate the leaves ; and afterwards the basket with the leaves is lifted up as often, and receives a circular shake to bring these towards the centre. The leaves are now taken back to the hot pans, and spread out in them as before, being again turned with the naked hand, and when hot taken out and rolled : after which they are put into the drying basket, and spread on a sieve which is in the centre of the basket, and the whole placed over a charcoal fire. The fire is very nicely regulated ; there must not be the least smoke, and the charcoal should be well picked.

When the fire is lighted, it is fanned until it gets a fine red glare, and the smoke is all gone off ; being every now and then stirred and the coals brought into the centre, so as to leave the outer edge low. When the leaves are put into the drying basket, they are gently separated by lifting them up with the fingers of both hands extended far apart, and allowing them to fall down again ; they are placed 3 or 4 inches deep on the sieve, leaving a passage in the centre for the hot air to pass. Before it is put over the fire, the drying basket receives a smart slap with both hands in the act of lifting it up, which is done to shake down any leaves that might otherwise drop through the sieve, or to prevent them from falling into the fire and occasioning a smoke, which would affect and spoil the tea. This slap on the basket is invariably applied throughout the stages of the

tea manufacture. There is always a large basket underneath to receive the small leaves that fall, which are afterwards collected, dried, and added to the other tea; in no case are the baskets or sieves permitted to touch or remain on the ground, but always laid on a receiver with three legs. After the leaves have been half dried in the drying basket, and while they are still soft, they are taken off the fire, and put into large open-worked baskets, and then put on the shelf, in order that the tea may improve in colour.

Next day the leaves are all sorted into large, middling, and small; sometimes there are four sorts. All these, the Chinese informed me, become so many different kinds of teas; the smallest leaves they called Pha-ho, the second Pow-chong, the third Su-chong, and the fourth, or the largest leaves, Toy-chong. After this assortment they are again put on the sieve in the drying basket (taking great care not to mix the sorts), and on the fire, as on the preceding day; but now very little more than will cover the bottom of the sieve is put in at one time, the same care of the fire is taken as before, and the same precaution of tapping the drying basket every now and then. The tea is taken off the fire with the nicest care, for fear of any particle of the tea falling into it. Whenever the drying basket is taken off, it is put on the receiver, the sieve in the drying basket taken out, the tea turned over, the sieve replaced, the tap given, and the basket placed again over the fire. As the tea becomes crisp, it is taken out and thrown into a large receiving basket, until all the quantity on hand has become alike dried and crisp; from which basket it is again removed into the drying basket, but now in much larger quantities. It is then piled up eight and ten inches high on the sieve in the drying basket; in the centre a small passage is left for the hot air to ascend; the fire that was before bright and clear, has now ashes thrown on it to deaden its effect, and the shakings that have been collected are put on the top of all; the tap is given, and the basket with the greatest care is put over the fire. Another basket is placed over the whole, to throw back any heat that may ascend. Now and then it is taken off, and put on the receiver; the hands, with the fingers wide apart, are run down the sides of the basket to the sieve, and the tea gently turned over, the passage in the centre again made, &c., and the basket again placed on the fire. It is from time to time examined, and when the leaves have become so crisp that they break by the slightest pressure of the fingers, it is taken off, when the tea is ready. All the different kinds of leaves underwent the same operation. The tea is now little by little put into boxes, and first pressed down with the hands and then with the feet (clean stockings having been previously put on).

There is a small room inside of the tea-house, 7 cubits square and 5 high, having bamboos laid across on the top to support a network of bamboo, and the sides of the room smeared with mud to exclude the air. When there is wet weather, and the leaves cannot be dried in the sun, they are laid out on the top of this room, on the network, on an iron pan, the same as is used to heat the leaves; some fire is put into it, either of grass or bamboo, so that the flame may ascend high; the pan is put on a square wooden frame, that has wooden rollers on its legs, and pushed round and round this little room by one man, while another feeds the fire, the leaves on the top being occasionally turned; when they are a little withered, the fire is taken away, and the leaves brought down and manufactured into tea, in the same manner as if it had been dried in the sun. But this is not a good plan, and never had recourse to, if it can possibly be avoided.

Tea imported into the United Kingdom, in 1850, 50,512,384 lbs.; in 1851, 71,466,460 lbs. Retained for home consumption, in 1850, 51,178,215 lbs.; in 1851, 53,965,112 lbs. Duty received, in 1850, 5,597,708*l.*; in 1851, 5,902,433*l.*

TEASEL, the head of the thistle (*Dipsacus*), is employed to raise the nap of cloth. See WOOLLEN MANUFACTURE.

TEETH. See BONES.

TELEGRAPHS, ELECTRICAL, PRUSSIAN. These telegraphs are used on all Prussian government lines, and on most of the railway lines of Northern Germany, making a total of about 3,000 miles; besides extensive lines which at present are in course of construction in Russia and other countries.

Indicating Telegraphs.—Keys are arranged round a dial, each key bearing a letter of the alphabet; one line wire is used, which connects two or more instruments at different stations. A hand on each dial revolves in concert with the hands on the remaining instruments; but by pressing down a key on any of them, all the hands stop, pointing to the same letter, until the key is again released. These instruments differ essentially from other telegraphs, inasmuch as they are entirely electrical machines, which break and reclose their own contacts in a similar manner as a steam-engine works its slide.

The electric current in passing through the line wire, and the coils in each instrument cause the armatures to be attracted by its motion to break the circuit; the armatures are then quite at liberty to fall back, and in so doing each instrument re-establishes the circuit, and the succeeding stroke takes place. In pressing down a key, the armature is stopped from falling back, and consequently no current can pass through the line wire

until it is released. The motion of the armature is transferred to a notched wheel, the spindle of which carries the hand on the dial. In the same case with each telegraph is an alarm, which is also worked by the electric circuit, only at the time when the commutator arm is placed in the position of "rest," and that of another station is moved on "telegraphs." The alarm continues to sound until the arm of the telegraph, which is to receive a message, is also placed on the telegraph, when the instruments begin to work, making about 35 revolutions, or 1,050 double strokes of the armature per minute.

Printing telegraphs are also worked by the electric current only, without the aid of clockwork. Their arrangement is similar to that of the indicating telegraph. In place of the hand on the dial, there is a type wheel with 30 springs, each carrying a type; it stops with the hand of the indicating telegraph, at which moment a hammer placed below the wheel strikes against it, and prints the letter on a strip of paper, which passes over a blackened roller turning round with it so as always to offer new surfaces to the hammer. The hammer is worked by a magnet, which is excited by the same battery which works the type wheel: its current is continually broken and restored by the movements of the armature of the type wheel; but as the type wheel stops, the current becomes permanent, and accumulates sufficient power to raise the hammer, which in so doing breaks its own current and falls back again.

The printing telegraph is placed always by the side of the indicating telegraph, and records each message on both or all stations.

By this means mistakes in the transmission of the messages are made morally impossible. The current being always broken on both or all the stations, currents arising from bad insulation of the line wire will not influence the harmonious working of the instruments, as long as these currents are not strong enough to work one or the other instruments by their own action, and the receiver of the message will always be able to interrupt and speak to the communicator. Besides, an unlimited number of telegraphs and other instruments for communicating particular signals may be included in the circuit of the same line-wire.

2. Another telegraph is peculiarly adapted to record on both stations the message delivered by the common English needle telegraph. Two magnets by means of two pins make dots in two different lines on a strip of paper which is moved by clockwork. Dots on the upper line correspond with a movement of the needle to the right, and dots on the lower line correspond with that to the left.

Instead of needle telegraphs peculiar communicating instruments may be used, consisting either of a pair of keys only, or of a complete key-board, which by pressing down one of them causes the conventional sign representing the letter marked on it to be printed in a double line of dots.

3. A double needle telegraph, with electro-magnets and worked by one line-wire.

4. An alarm, by which intermediate stations, when excluded from the line-wire, may be recalled into the circuit.

5. An alarm with two large cast-iron bells, which are placed on level crossings, &c., along railways and serve to announce the departure of each train along the line. The bells are surrounded by clockwork, which is released by a current of longer duration than is required to work the telegraphs.

6. An instrument which is used to detect bad insulation in the gutta serena coated line-wire.

7. A galvanometer to test the insulation of the line-wire, and another by which defects in the line-wire may be pointed out, without leaving the end stations.

8. Gutta serena coated electric line-wire, which was first invented by Mr. Sumens, and applied by him on a large scale, since 1847.

9. An improved Morse's telegraph worked by secondary power.

TELLURIUM, is a metal too rare and high-priced to be used in the arts.

TERRA-COTTA, literally baked clay, is the name given to statues, architectural decorations, figures, vases, &c., modelled or cast in a paste made of pipe or potter's clay and a fine-grained colourless sand, from Ryegate, with pulverized potsherds, slowly dried in the air, and afterwards fired to a stony hardness in a proper kiln. See STONE, ARTIFICIAL.

TERRA DI SIENA, is a brown ferruginous ochre, employed in painting.

TEST LIQUORS. To reduce an alkaline, acid, or a neutral saline solution of a certain strength to one of any other strength. Let a = the given strength per cent. of one liquid; b = 100; c = the desired strength; x = the volume of the diluted solution.

Example. Let an alkaline solution contain 40 per cent. of alkali: if it is to be reduced to one containing 24 per cent., then the above formula gives $\frac{a b}{c} = x = \frac{4000}{24} = 166.6$;

hence if 100 measures of the liquid a be diluted into 166 measures, it will then contain 24 per cent.

TESTS, are chemical reagents of any kind, which indicate, by special characters,

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THE PESTA

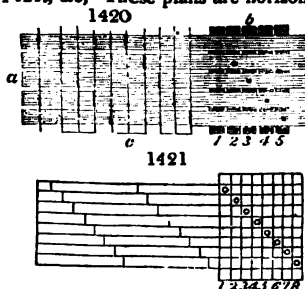
| | | | |
|----------------|--|---------------|--|
| SILVER | A yellow precipitate soluble in excess, insoluble in free acids. | A | No precipitate. |
| GOLD | A yellow precipitate. | A | A dark colour, an shortly the Gold precipitated. |
| TIN, PROTOXIDE | A white precipitate insoluble in excess. | A, b, c | A white precipitate. |
| TIN, PEROXIDE | A white precipitate, soluble in acids and in excess. | T, c | No precipitate. |
| ANTIMONY | A white precipitate, insoluble in excess and in Muriatic Acid. | T, b | A white precipitate caused by water. |
| CHROMIUM | A greenish blue precipitate, insoluble in excess. | A, a, b, c, d | No precipitate. |
| VANADIUM | A grayish white precipitate, turning red and dissolving. | TT | |
| COLUMBIUM | Is easily dissolved, and may be again precipitated by acids. | Th, b | Dissolves the Oxide. |
| IRIDIUM | A brown precipitate, partly soluble, forming a purple solution. | A, c, d | |
| RHODIUM | Shortly a lemon yellow colour. | A, a, d | |
| PALLADIUM | A yellowish precipitate, slightly soluble in excess. | A, b, N | No action. |
| OSMIUM | No precipitate: solution turns yellow. | Fu, w, w | Turns darker, but is not precipitated. |
| TELLURIUM | A white precipitate, soluble in excess. | A, so, pt | |
| TITANIUM | A white precipitate, insoluble in excess. | Th | A white flocculent precipitate. |
| TUNGSTEN | The Acid dissolves, but is again precipitated by stronger acids. | Th | |
| URANIUM | A brown flaky precipitate, insoluble in excess. | A, J, ta, ce | |
| MOLYBDENUM | The Acid is dissolved and the Protoxide forms a brown precipitate. | Th, ta, ce | |

th to in



be nature of any substance, simple or compound. See ASSAY, the several metals acids, &c.

TEXTILE FABRICS. The first business of the weaver is to adapt those parts of his loom which move the warp, to the formation of the various kinds of ornamental figures which the cloth is intended to exhibit. This subject is called the *draught*, drawing or reading in, and the cording of looms. In every species of weaving, whether direct or cross, the whole difference of pattern or effect is produced, either by the succession in which the threads of warp are introduced into the heddles, or by the succession in which those heddles are moved in the working. The heddles being stretched between two shafts of wood, all the heddles connected by the same shafts are called a leaf; and as the operation of introducing the warp into any number of leaves is called drawing a warp, the plan of succession is called the draught. When this operation has been performed correctly, the next part of the weaver's business is to connect the different leaves with the levers or treddles by which they are to be moved, so that one or more may be raised or sunk by every treddle successively, as may be required to produce the peculiar pattern. These connections being made by coupling the different parts of the apparatus by cords, this operation is called the cording. In order to direct the operator in this part of his business, especially if previously unacquainted with the particular pattern upon which he is employed, plans are drawn upon paper, specimens of which will be found in *figs.* 1420, 1421., &c. These plans are horizontal sections of a loom, the heddles being represented



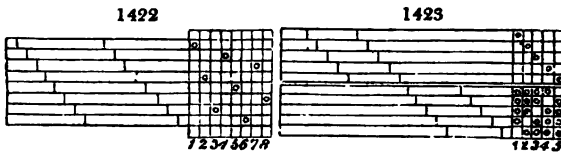
across the paper at *a*, and the treddles under them, and crossing them at right angles at *b*. In *figs.* 1420. and 1421. they are represented as if they were distinct pieces of wood, those across being the under shaft of each leaf of heddles, and those at the left hand the treddles. See **WEAVING**. In actual weaving, the treddles are placed at right angles to the heddles, the sinking cords descending perpendicularly as nearly as possible to the centre of the latter. Placing them at the left hand, therefore, is only for ready inspection, and for practical convenience. At *c* a few threads of warp are shown as they pass through the heddles, and the thick lines denote the leaf with which each thread is connected.

Thus, in *fig.* 1420., the right-hand thread, next to *a*, passes through the eye of a heddle upon the back leaf, and is disconnected with all the other leaves; the next thread passes through a heddle on the second leaf; the third, through the third leaf; the fourth, through the fourth leaf; and the fifth, through the fifth or front leaf. One set of the draught being now completed, the weaver recommences with the back leaf, and proceeds in the same succession again to the front. Two sets of the draught are represented in this figure, and the same succession, it is understood by weavers (who seldom draw more than one set), must be repeated until all the warp is included. When they proceed to apply the cords, the right-hand part of the plan at *b* serves as a guide. In all the plans shown by these figures, excepting one which shall be noticed, a connexion must be formed, by cording, between every leaf of heddles and every treddle; for all the leaves must either rise or sink. The raising motion is effected by coupling the leaf to one end of its correspondent top lever; the other end of this lever is tied to the long march below, and this to the treddle. The sinking connexion is carried directly from under the leaf to the treddle. To direct a weaver which of these connexions is to be formed with each treddle, a black spot is placed when a leaf is to be raised, where the leaf and treddle intersect each other upon the plan, and the sinking connexions are left blank. For example, to cord the treddle 1, to the back leaf, put a raising cord, and to each of the other four, sinking cords; for the treddle 2, raise the second leaf, and sink the remaining four, and so of the rest; the spot always denoting the leaf or leaves to be raised. The *figs.* 1420. and 1421. are drawn for the purpose of rendering the general principle of this kind of plans familiar to those who have not been previously acquainted with them; but those who have been accustomed to manufacture and weave ornamental cloths, never consume time by representing either heddles or treddles as solid or distinct bodies. They content themselves with ruling a number of lines across a piece of paper, sufficient to make the intervals between these lines represent the number of leaves required. Upon these intervals, they merely mark the succession of the draught, without producing every line to resemble a thread of warp. At the left hand, they draw as many lines across the former as will afford an interval for each treddle; and in the squares produced by the intersections of these lines, they place the dots, spots or cyphers which denote the raising cords. It is also common to continue the cross lines which denote the treddle a considerable length beyond the intersections, and to mark by dots, placed diagonally in the intervals, the order or

succession in which the treddles are to be pressed down in weaving. The former of these modes has been adopted in the remaining *figs.* to 1429; but to save room, the latter has been avoided, and the succession marked by the order of the figures under the intervals which denote the treddles.

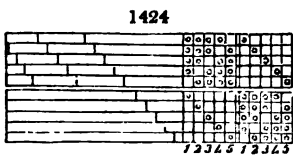
Some explanation of the various kinds of fanciful cloths represented by these plans, may serve further to illustrate this subject, which is, perhaps, the most important of any connected with the manufacture of cloth, and will also enable a person who thoroughly studies them, readily to acquire a competent knowledge of the other varieties in weaving, which are boundless. *Figs.* 1420. and 1421. represent the draught and cording of the two varieties of tweeled cloth wrought with five leaves of heddles. The first is the regular or run tweel, which, as every leaf rises in regular succession, while the rest are sunk, interweaves the warp and woof only at every fifth interval, and as the succession is uniform, the cloth, when woven, presents the appearance of parallel diagonal lines, at an angle of about 45° over the whole surface. A tweel may have the regularity of its diagonal lines broken by applying the cording as in *fig.* 1421. It will be observed, that in both figures the draught of the warp is precisely the same, and that the whole difference of the two plans consists in the order of placing the spots denoting the raising cords, the first being regular and successive, and the second alternate.

Figs. 1422 and 1423. are the regular and broken tweels which may be produced with eight leaves. This properly is the tweel denominated satin in the silk manufacture,



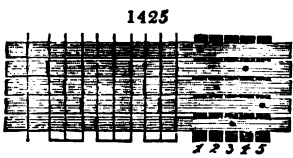
although many webs of silk wrought with only five leaves receive that appellation. Some of the finest Florentine silks are tweeled with sixteen leaves.

When the broken tweel of eight leaves is used, the effect is much superior to what could be produced by a smaller number; for in this two leaves are passed in every interval, which gives a much nearer resemblance to plain cloth than the others. For this reason it is preferred in weaving the finest damasks. The draught of the eight-leaf tweel differs in nothing from the others, excepting in the number of leaves. The difference of the cording in the broken tweel will appear by inspecting the cyphers which mark the raising cords, and comparing them with those of the broken tweel of five leaves. *Fig.* 1424. represents the draught and cording of striped dimity of a tweel of five leaves. This is the most simple species of fanciful tweeling. It consists of ten leaves, or double the number of the common tweel.



These ten leaves are moved by only five treddles, in the same manner as a common tweel. The stripe is formed by one set, of the leaves flushing the warp, and the other set, the woof. The figure represents a stripe formed by ten threads, alternately drawn through each of the two sets of leaves. In this case, the stripe and the intervals will be equally broad,

and what is the stripe upon one side of the cloth, will be the interval upon the other, and *vice versa*. But great variety of patterns may be introduced by drawing the warp in greater or smaller portions through either set. The tweel is of the regular kind, but may be broken by placing the cording as in *fig.* 1421. It will be observed that the cording-marks of the lower or front leaves are exactly the converse of the other set; for where a raising mark is placed upon one, it is marked for sinking in the other; that is to say, the mark is omitted; and all leaves which sink in the one, are marked for raising in the other; thus, one thread rises in succession in the back set, and

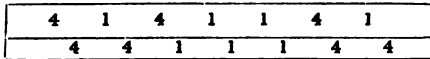


four sink; but in the front set, four rise, and only one sinks. The woof, of course, passing over the four sunk threads, and under the raised one, in the first instance, is flushed above; but where the reverse takes place, as in the second, it is flushed below; and thus the appearance of a stripe is formed. The analogy subsisting between striped dimity and dornock is so great, that before noticing the plan

for fancy dimity, it may be proper to allude to the dornock, the plan of which is represented by *fig.* 1425.

The draught of dornock is precisely the same in every respect with that of striped dimity. It also consists of two sets of tweeling-heddles, whether three, four, or five leaves are used for each set. The right-hand set of treddles is also corded exactly in the same way, as will appear by comparing them. But as the dimity is a continued stripe

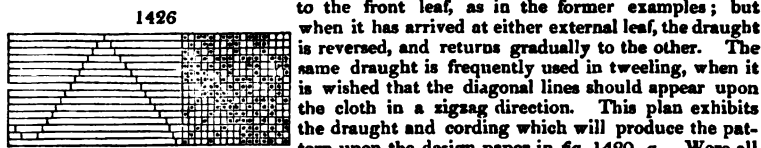
from the beginning to the end of the web, only five treddles are required to move ten leaves. The dornock being checker-work, the weaver must possess the power of reversing this at pleasure. He therefore adds five more treddles, the cording of which is exactly the reverse of the former; that is to say, the back leaves, in the former case, having one leaf raised, and four sunk, have, by working with these additional treddles, one leaf sunk and four leaves raised. The front leaves are in the same manner reversed, and the mounting is complete. So long as the weaver continues to work with either set, a stripe will be formed, as in the dimity; but when he changes his feet from one set to the other, the whole effect is reversed, and the checkers formed. The dornock pattern upon the design paper, *fig. 1425*, may be thus explained: let every square of the design represent five threads upon either set of the heddles, which are said by weavers to be once over the draught, supposing the tweel to be one of five leaves; draw three parallel lines, as under, to form two intervals, each representing one of the sets; the draught will then be as follows:—



The above is exactly so much of the pattern as is there laid down, to show its appearance; but one whole range of the pattern is completed by the figure 1, nearest to the right hand upon the lower interval between the lines, and the remaining figures, nearer to the right, form the beginning of a second range or set. These are to be repeated in the same way across the whole warp. The lower interval represents the five front leaves; the upper interval, the five back ones. The first figure 4, denotes that five threads are to be successively drawn upon the back leaves, and this operation repeated four times. The first figure 4, in the lower interval, expresses that the same is to be done upon the front leaves; and each figure, by its diagonal position, shows how often, and in what succession, five threads are to be drawn upon the leaves which the interval in which it is placed represents.

Dornocks of more extensive patterns are sometimes woven with 3, 4, 5, and even 6 sets of leaves; but after the leaves exceed 15 in number, they both occupy an inconvenient space, and are very unwieldy to work. For these reasons the diaper harness is in almost every instance preferred.

Fig. 1426, represents the draught and cording of a fanciful species of dimity, in which it will be observed that the warp is not drawn directly from the back to the front leaf, as in the former examples; but



when it has arrived at either external leaf, the draught is reversed, and returns gradually to the other. The same draught is frequently used in tweeling, when it is wished that the diagonal lines should appear upon the cloth in a zigzag direction. This plan exhibits the draught and cording which will produce the pattern upon the design-paper in *fig. 1420. a*. Were all the squares produced by the intersection of the lines denoting the leaves and treddles, where the raised dots are placed, filled the same as on the design, they would produce the effect of exactly one-fourth of that pattern. This is caused by the reversing of the draught, which gives the other side reversed as on the design; and when all the treddles, from 1 to 16, have been successively used in the working, one-half of the pattern will become complete. The weaver then goes again over his treddles, in the reversed order of the numbers, from 17 to 30, when the other half of the pattern will be completed. From this similarity of the cording to the design, it is easy, when a design is given, to make out the draught and cording proper to work it; and when the cording is given to see its effect upon the design.

Fig. 1427, represents the draught of the diaper mounting, and the cording of the front leaves which are moved by treddles. From the plan, it will appear that 5 threads are included in every mail of the harness, and that these are drawn in single threads through the front leaves. The cording forms an exception to the general rules, that when one or more leaves are raised, all the rest must be sunk; for in this instance, one leaf rises, one sinks, and three remain stationary. An additional mark, therefore, is used in this plan. The dots, as formerly, denote raising cords; the blanks, sinking cords; and where the cord is to be totally omitted, the cross marks x are placed.

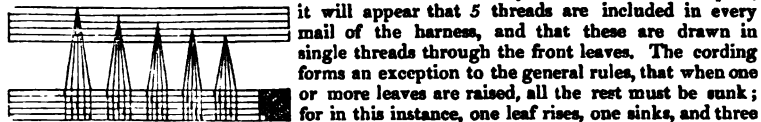
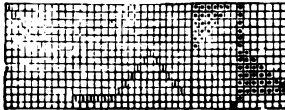


Fig. 1428, is the draught and cording of a spot whose two sides are similar, but re-

versed. That upon the plan forms a diamond, similar to the one drawn upon the design paper in the diagram, but smaller in size. The draught here is reversed, as in the dimity plan, and the treading is also to be reversed, after arriving at 6, to complete the diamond. Like it, too, the raising marks form one-fourth of the pattern. In weaving spots, they are commonly placed at intervals, with a portion of plain cloth between them, and in alternate rows, the spots of one row being between those of the other. But as intervals of plain cloth must take place, both by the warp and woof, 2 leaves are added for that purpose. The front, or ground leaf, includes every second thread of the whole warp; the second, or plain leaf, that part which forms the intervals by the warp. The remaining leaves form the spots; the first six being allotted to one row of spots, and the second six to the next row; where each spot is in the centre between the former. The reversed draught of the first

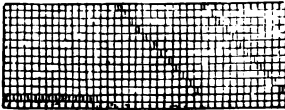
1428



is shown entire, and is succeeded by 12 threads of plain. One-half of the draught of the next row is then given, which is to be completed exactly like the first, and succeeded by 12 threads more of plain; when, one set of the pattern being finished, the same succession is to be repeated over the whole warp. As spots are formed by inserting woof of coarser dimensions than that which forms the fabric, every second thread only is allotted for the spotting. Those included in the front, or ground leaf, are represented by lines, and the spot threads between them, by marks in the intervals, as in the other plans.

The treddles necessary to work this spot are, in number, 14. Of these the two in the centre, *a*, *b*, when pressed alternately, will produce plain cloth; for *b* raises the front leaf which includes half of the warp, and sinks all the rest; while *a* exactly reverses the operation. The spot-treddenes on the right hand work the row contained in the first six spot-leaves: and those upon the left hand, the row contained in the second six. In working spots, one thread, or shot of spotting-woof, and two of plain, are successively inserted, by means of two separate shuttles.

1429



Disimilar spots are those whose sides are quite different from each other. The draught only of these is represented by *fig. 1429*. The cording depends entirely upon the figure.

Fig. 1430, represents any solid body composed of parts *lashed* together. If the darkened squares be supposed to be beams of wood, connected by cordage, they will give a precise idea of textile fabric. The beams cannot come into actual contact, because, if the *lashing* cords were as fine even as human hairs, they must still require

1430



space. The thickness is that of one beam and one cord; but if the cords touch each other, it may then be one beam and two cords; but it is not possible in practical weaving to bring every thread of weft into actual contact. It may therefore be assumed, that the thickness is equal to the diameter of one thread of the warp, added to that of one yarn of the weft; and when these are equal, the thick-

1431



ness of the cloth is double of that diameter. Denser cloth would not be sufficiently pliant or flexible.

Fig. 1431, is a representation of a section of cloth of an open fabric, where the round dots which represent the warp are placed at a considerable distance from each other.

Fig. 1432, may be supposed a plain fabric of that description which approaches the most nearly to any idea we can form of the most dense or close contact of which yarn can be made susceptible. Here the warp is supposed to be so tightly stretched in the loom as to retain entirely the parallel state, without any curvature, and the whole flexure is therefore given to the woof. This mode of

1432



weaving can never really exist; but if the warp be sufficiently strong to bear any tight stretching, and the woof be spun very soft and flexible, something very near it may be produced. This way of making cloth is well fitted for those goods which require to give considerable warmth; but they are sometimes the means of very gross fraud and imposition; for if the warp is made of very slender threads, and the woof of slackly twisted cotton or woollen yarn, where the fibrils of the stuff, being but slightly brought into contact, are rough and oozy, a great appearance of thickness and strength may be given to the eye, when the cloth is absolutely so flimsy that it may be torn asunder as easily as a sheet of writing-paper. Many frauds of this kind are practised.

In *fig. 1433.* is given a representation of the position of a fabric of cloth in section, as it is in the loom before the warp has been closed upon the woof, which still appears as a straight line. This figure may usefully illustrate the direction and ratio of contraction which must unavoidably take place in every kind of cloth, according to the density of the texture,

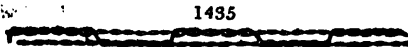


the dimensions of the threads, and the description of the cloth. Let Λ, β , represent one thread of woof completely stretched by the velocity of the shuttle in passing between the threads of warp which are represented by the round dots 1, 2, &c., and those distinguished by 8, 9, &c. When these threads are closed by the operation of the needles to form the inner texture, the first tendency will be to move in the direction 1 β , 2 β , &c., for those above, and in that of 8 α , 9 α , &c., for those below; but the contraction for Λ, β , by its deviation from a straight to a curved line, in consequence of the compression of the warp threads 1 β , 2 β , &c., and 1 α , 2 α , &c., in closing, will produce, by the action of the two powers at right angles to each other, the oblique or diagonal direction denoted by the lines 1, 8—2, 9, to the left, for the threads above, and that expressed by the lines 2, 8—3, 9, &c., to the right, for the threads below. Now, as the whole deviation is produced by the flexure of the thread Λ, β , if Λ is supposed to be placed at the middle of the cloth, equidistant from the two extremities, or *setvoes* as they are called by weavers, the thread at 1 may be supposed to move really in the direction 1 β , and all the others to approach to it in the directions represented, whilst those to the right would approach to it in the same ratio, but the line of approximation would be inverted. *Fig. 1434.*



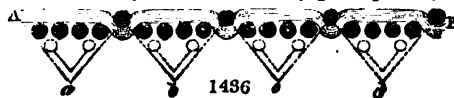
represents that common fabric used for lawns, muslins, and the middle kind of goods, the excellence of which neither consists in the greatest strength, nor in the greatest transparency. It is entirely a medium between *fig. 1431.* and *fig. 1432.*

In the efforts to give great strength and thickness to cloth, it will be obvious that the common mode of weaving, by constant intersection of warp and woof, although it may be perhaps the best which can be devised for the former, presents invincible obstructions to the latter beyond a certain limit. To remedy this, two modes of weaving are in common use, which, while they add to the power of compressing a great quantity of materials in a small compass, possess the additional advantage of affording much facility for adding ornament to the superficies of the fabric. The first of these is double cloth, or two webs woven together, and joined by the operation. This is chiefly used for carpets; and its geometrical principles are entirely the same as those of plain cloth, supposing the webs



to be sewed together. A section of the cloth will be found in *fig. 1435.* See CARPETS. Of the simplest kind of tweeled fabric, a section is given in *fig. 1436.*

The great and prominent advantage of the tweeled fabric in point of texture, arises from the facility with which a very great quantity of materials may be put closely together. In the figure, the warp is represented by the dots in the same straight line as in the plain fabrics; but if we consider the direction and ratio of contraction,



upon principles similar to those laid down in the explanation given of *fig. 1433.*, we shall readily discover the very different way in which the tweeled fabric is affected.

When the dotted lines are drawn at a, b, c, d , their direction of contraction, instead of being upon every second or alternate thread, is only upon every fifth thread, and the natural tendency would consequently be, to bring the whole into the form represented by the lines and dotted circles at a, b, c, d . In point, then, of thickness, from the upper to the under superficies, it is evident that the whole fabric has increased in the ratio of nearly three to one. On the other hand, it will appear, that four threads or cylinders being thus put together in one solid mass, might be supposed only one thread, or like the strands of a rope before it is twisted; but, to remedy this, the thread being shifted every time, the whole forms a body in which much aggregate matter is compressed; but where, being less firmly united, the accession of strength acquired by the accumulation of materials is partially counteracted by the want of equal firmness of junction.

The second quality of the tweeled fabric, *susceptibility of receiving ornament*, arises from its capability of being inverted at pleasure, as in *fig. 1437.* In this figure we have, as before, four threads, and one alternately inter-



sected; but here the four threads marked 1 and 2 are under the woof, while those marked 3 and 4 are above.

Fig. 1438. represents that kind of tweeled work which produces an ornamental effect, and adds even to the strength of a fabric, in so far as accumulation of matter can be considered in that light. The figure



represents a piece of velvet cut in section, and of that kind which, being woven upon a tweeled ground, is known by the name of Genoa velvet. 1st. Because, by combining a great quantity of material in a small compass, they afford great warmth. 2nd. From the great resistance which they oppose to external friction, they are very durable. And, 3rd. Because, from the very nature of the texture, they afford the finest means of rich ornamental decoration.

The use of velvet cloths in cold weather is a sufficient proof of the truth of the first. The manufacture of plush, corduroy, and other stuffs for the dress of those exposed to the accidents of laborious employment, evinces the second; and the ornamented velvets and Wilton carpeting are demonstrative of the third of these positions.

In the figure, the diagonal form which both the warp and woof of cloth assume, is very apparent from the smallness of the scale. Besides what this adds to the strength of the cloth, the flushed part, which appears interwoven at the darkly shaded intervals 1, 2, &c., forms, when finished, the whole covering or upper surface. The principle, in so far as regards texture, is entirely the same as any other tweeled fabric.

Fig. 1439., which represents corduroy, or king's cord, is merely striped velvet. The principle is the same, and the figure shows that the one is a copy of the other.



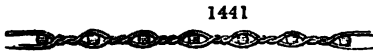
The remaining figures represent those kinds of work which are of the most flimsy and open description of texture; those in which neither strength, warmth, nor durability

are much required, and of which openness and transparency are the chief recommendations.

Fig. 1440. represents common gauze, or *linax*, a substance very much used for various purposes. The essential difference between this description of cloth and all others,

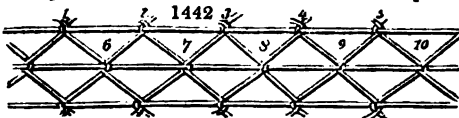


consists in the warp being turned or twisted like a rope during the operation of weaving, and hence it bears a considerable analogy to *lace*. The twining of gauze is not continued in the same direction, but is alternately from right to left, and *vice versa*, between every intersection of the woof. The fabric of gauze is always open, flimsy, and transparent; but, from the turning of the warp, it possesses an uncommon degree of strength and tenacity in proportion to the quantity of material which it contains. This quality, together with the transparency of the fabric, renders it peculiarly adapted for ornamental purposes of various kinds, particularly for flowering or figuring, either in the loom, or by the needle. In the warp of gauze, there arises a much greater degree of contraction during the weaving, than in any other species of cloth; and this is produced by the turning. The twisting between every intersection of woof amounts precisely to one complete revolution of both threads; hence this difference exists between this and every other



species of weaving, namely, that the one thread of warp is always above the woof and the contiguous thread is always below. Fig. 1441. represents a section of another species of twisted cloth, which is known by the name of catgut, and which differs from the gauze only, by being subjected to a greater degree of twine in weaving; for in place of one revolution between each intersection, a revolution and a half is always given; and thus the warp is alternately above and below, as in other kinds of weaving.

Fig. 1442. is a superficial representation of the most simple kind of ornamental net-work produced in the loom. It is called a whip-net by weavers, who use the term *whip*



for any substance interwoven in cloth for ornamental purposes when it is distinct from the ground of the fabric. In this the difference is merely in the crossing of the warp; for it is very evident that the crossings at 1, 2, 3, 4, and 5, are of different threads from those at 6, 7, 8, and 9.

Fig. 1443. represents, superficially, what is called the mail-net, and is merely a combination of common gauze and the whip-net in the same fabric. The gauze here being

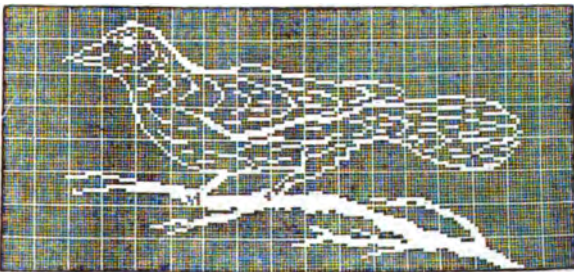
1443



the hypotenuses. The contraction here being very different, it is necessary that the gauze and whip parts should be stretched upon separate beams.

In order to design ornamental figures upon cloths, the lines which are drawn from the top to the bottom of the paper may be supposed to represent the warp; and those drawn across, the woof of the web; any number of threads being supposed to be included between every two lines. The paper thus forms a double scale, by which, in the first instance, the size and form of the pattern may be determined with great precision; and the whole subsequent operations of the weaver regulated, both in mounting and working his loom. To enable the projector of a new pattern to judge properly of its effects, when transferred from the paper to the cloth, it will be essentially necessary that he should bear constantly in his view the comparative scale of magnitude which the design will bear in each, regulating his ideas always by square or superficial measurement. Thus, in the large design, *Fig. 1444.*, representing a bird perched upon the branch of a tree, it will be proper, in the first place, to count the number of spaces from the point of the bill to the extremity of the tail; and to render this the more easy, it is to be observed that every tenth line is drawn considerably bolder than the others. This number in the design is 135 spaces. Counting again, from the stem of the branch to the upper part of the bird's head, he will find 76 spaces. Between these spaces, there-

1444



fore, the whole superficial measure of the pattern is contained. By the measure of the paper, this may be easily tried with a pair of compasses, and will be found to be nearly $6\frac{1}{2}$ inches in length, by $3\frac{1}{2}$ inches in breadth. Now, if this is to be woven in a reed containing 800 intervals in 37 inches, and if every interval contains five threads, supposed to be contained between every two parallel lines, the length will be 6.24 inches, and the breadth 3.52 inches nearly; so that the figure upon the cloth would be very nearly of the same dimensions as that upon the paper; but if a 1200 reed were used, instead of an 800, the dimension would be proportionally contracted.

A correct idea being formed of the design, the weaver may proceed to mount his loom according to the pattern; and this is done by two persons, one of whom takes from the design instructions necessary for the other to follow in tying his cords.

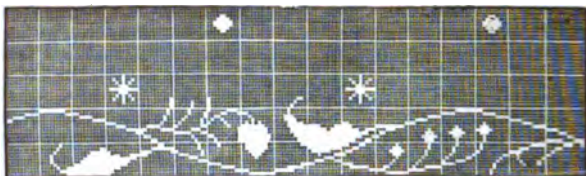
Fig. 1445. is a representation of the most simple species of table-linen, which is merely

1445



an imitation of checker-work of various sizes; and is known in Scotland, where the manufacture is chiefly practised, by the name of Dornock. When a pattern is formed upon tweeled cloth, by reversing the flushing, the two sides of the fabric being dissimilar, one may be supposed to be represented by the black marks, and the other by the part of the figure which is left uncoloured. For such a pattern as this, two sets of common tweeled-heddles, moved in the ordinary way, by a double succession of heddles, are sufficient. The other part of *Fig. 1445.* is a design of that intermediate kind of ornamental work which is called diaper, and which partakes partly of the nature of the dornock, and partly of that of the damask and tapestry. The principle upon which all these descriptions of goods are woven is entirely the same, and the only difference is in the

1446



extent of the design, and the means by which it is executed. Fig. 1446. is a design for a border of a handkerchief or napkin, which may be executed either in the manner of damask, or as the spotting is practised in the lighter fabrics.

Textile fibres condensed. Mr. John Mercer's novel plan of transforming cotton and flax into fibres of a fine silky texture, while their strength and substance are increased, has recently excited much interest. He subjects them to the action of caustic alkaline lye, sulphuric acid, or to solution of chloride of zinc, of such strength and at such a temperature as produces certain remarkable changes in them, quite the reverse of what most people would have expected. The mode of operating according to this invention, upon cloth made wholly or partially of any vegetable fibres and bleached, is as follows:—The cloth is passed through a padding machine charged with caustic soda or caustic potash at 60° or 70° of Twaddle's hydrometer, at the common temperature of the atmosphere (say 60° Fahr. or under); then, without being dried, it is washed in water; and, after this, it is passed through dilute sulphuric acid, and washed again. Or the cloth is conducted over and under a series of rollers in a cistern containing caustic soda or caustic potash at 40° to 50° Twaddle, at the ordinary temperature (the last two rollers being set so as to squeeze the excess of soda or potash back into the cistern); and then it is passed over and under rollers placed in a series of cisterns, which are charged at the commencement of the operation with water only; so that when the cloth arrives at the last cistern, nearly all the alkali has been washed out of it. After the cloth has either gone through the padding machine or through the cisterns, it is washed in water, passed through dilute sulphuric acid, and again washed in water.

When grey or unbleached cloth, made from the above mentioned fibrous material, is to be treated, it is first boiled or steeped in water, so as to wet it thoroughly; then most of the water is removed by the squeezer or hydro-extractor; and, after this, it is passed through the soda or potash solution, &c., as before described.

Warps, either bleached or unbleached, are treated in the same manner; but, after passing through the cistern containing the alkali, they are passed through squeezers or through a hole in a metal plate, to remove the alkali; and then the warps are conducted through the water cisterns, "sourred," and washed, as before described.

When thread or hank yarn is to be operated upon, the threads or yarns are immersed in the alkali and then wrung out (as is usually done in sizing or dyeing them); and afterwards they are subjected to the above-mentioned operations of washing, souring, and washing in water.

When any fibre in the raw state, or before it is manufactured, is to be treated, it is first boiled in water, and then freed from most of the water by the hydro-extractor or a press; after which, it is immersed in the alkaline solution, and the excess of alkali is removed by the hydro-extractor or a press; then it is washed in water, soured with dilute sulphuric acid, and washed again; and finally the water is removed by the hydro-extractor or a press.

The following are the effects produced by the above operations upon cloth made of vegetable fibrous material, either alone or mixed with animal fibrous material:—the cloth will have shrunk in length and breadth, or have become less in its external dimensions, but thicker and closer; so that by the chemical action of caustic soda or caustic potash on cotton and other vegetable fabrics, an effect will be produced somewhat analogous to that which is produced on woollen by the process of fulling or milling; the cloth will likewise have acquired greater strength and firmness,—greater force being required to break each fibre,—it will be found to have become heavier than it was previously to being acted upon by the alkali; if in both cases it be weighed at the temperature of 60° Fahr., or under. It will also have acquired greatly augmented and improved powers of receiving colours in printing and dyeing.

The effects resulting from the above treatment of the vegetable fibre, in any of its various stages, before it is made into cloth, will be readily understood from the statement of the effects produced on cloth, composed of such fibre, by treating it according to this invention.

Secondly, the patentee employs diluted sulphuric acid, at 105° Twaddle, and at 60° Fahr. or under, instead of caustic soda or caustic potash, the operation being the same as when soda or potash is used, except the last souring, which is now unnecessary.

Thirdly, the patentee uses a solution of chloride of zinc, at 145° Twaddle, and from 150° to 160° Fahr., instead of the soda or potash, and in the same manner.

When operating on mixed fabrics, composed partly of vegetable fibres and partly of silk, wool, or other animal fibres, such as delaines, it is preferred that the strength of the alkali should not exceed 40° Twaddle, nor the temperature be above 50° Fahr., lest the animal fibres should be injured.

The apparatus and the temperature and strength of the soda or potash, sulphuric acid, or chloride of zinc solution, may be varied to a considerable extent, and will produce proportionate effects; for instance, the soda or potash may be used at a strength even as low as 20° Twaddle, and still give improved properties to cotton, &c., for receiving colours in printing and dyeing, particularly if the temperature be low; for the lower the temperature, the more effectually the soda or potash acts on the fibrous material. The patentee does not, therefore, confine himself to any particular strength or temperature; but he prefers the strength, heat, and process above described.

He claims, as his invention, the subjecting of cotton, linen, and other vegetable fibrous material, either in the fibre or any stage of its manufacture, either alone, or mixed with silk, woollen, or other animal fibrous material, to the action of caustic soda or caustic potash, dilute sulphuric acid, or solution of chloride of zinc, of a temperature and strength sufficient to produce the new effects, and give to them the new properties above described, either by padding, printing, or steeping, immersion, or any other mode of application.—*Newton's Journal*, xxxviii. p. 456.

For washing textile fabrics, Messrs. M'Alpin, of Hammersmith, have combined a rotating (centrifugal) wash vessel with vertical beaters; a very effective contrivance which may be seen at work at any time.

Textile Manufactures.—Commencing at the extreme west of the Great Exhibition we observe the extensive series contributed by Messrs. Hibbert, Platt, & Co., of Oldham, in illustration of the various operations in preparing and spinning cotton. The first operation is that of opening the entangled locks, and of partially freeing the fibres from extraneous substances. Instead of the "willy" commonly employed for this purpose, Messrs. Hibbert and Platt exhibit a novel apparatus of American origin. The principle of action in this machine is, that it draws the cotton between spiked and fluted rollers, so as to loosen the matted fibres by a drawing action, instead of by a rapidly revolving beater; the portions of seed and other impurities being separated by the rotation of other fluted rollers, which revolve against the fibres as they are held by the spikes, and thus effect the required cleaning. The cotton, as it comes from the bale, is spread upon an endless travelling apron, which carries it forwards and delivers it into the machine.

In the next machine, for further opening and cleansing the material, two arrangements are included, which are not generally employed, except by this firm. The scouring action is accomplished in the ordinary manner, the impurities falling below through an iron grating; the opened locks, however, having arrived at the other end of the machines pass over, instead of under, the exhausting apparatus, so that the dust removed therefrom by the draft is not compelled to pass through the sheet of cotton. There is also a peculiar arrangement of rollers, between and partly around which the web of cotton is conducted previously to being wound into a lap; the design being to effect a more perfect calendaring or consolidating of the fibres.

Six carding machines, which effect the next process, are exhibited; two of these only, however, are necessary to complete the perfect operation they are designed to effect, the remaining four being added merely for the purpose of supplying a sufficient quantity of carded cotton to meet the demand of the machining subsequently used. Referring then to two of these: the first used is called a breaker, and the lap of cotton from the last machine is placed so as to revolve in a portion of the framework, to effect an unwinding. According to the usual method, the material would pass through a pair of rollers, which, by their revolution, bring it under the action of the machine; here, however, the "patent feeder" is employed, consisting of a roller and concave surface, between which the sheet of cotton passes, and is from thence taken by a roller, called the "licker-in," covered with wire cards. From this roller the fibres are stripped by the revolution of the large central carding cylinder, and again teased and straightened by the action of other revolving carding surfaces. In many instances the whole process is accomplished by these means. In the case, however, of the exhibited machinery now under notice, there are in addition to the rollers a series of stationary surfaces, covered with wire cards, and having no concave form, corresponding to the periphery of a large revolving cylinder. The material passing between these combining surfaces, the one brushing over the other, becomes further straightened and separated, so as to be regularly diffused over the main carding surface; it is then removed therefrom by the doffer, and subsequently stripped in the form of a light fleecy sheet by the rapid chopping action of the doffer-comb. A trumpet-shaped orifice then narrows the sheet of cotton into a spongy cord, which is delivered by a set of revolving rollers

into a receiver placed below. This in many instances is simply a cylindrical can, sometimes provided with a rising and falling plunger, which, by pressing upon the top of the material, effects the stowage of a greater quantity than could otherwise be received into the can. Messrs. Tatham and Cheetham's patent "coiler" is now, however, fast superseding the old arrangements; and the estimation in which it is held is evinced by the fact of its application, instead of the old system, to all the preparing machinery in motion at the Exhibition. The construction of this apparatus, as adopted by Messrs. Hibbert and Platt, somewhat differs from that of the original patentees, but the principle of construction is the same. The sliver delivered by the rollers passes through revolving surfaces, which thus carry it round, and deposit it in circles, within a can placed below: this can, however, not being stationary but revolving upon a centre, eccentric to the centre of motion of the delivering surfaces, carries onward the sliver as it falls; and thereby, instead of allowing it to form a cylinder of cotton, disposes it in a series of coils throughout the area of the can. As the can becomes filled, the material rises against a plate at top; and the operation still proceeding, effects a pressing-down of the sliver, so as to produce a condensation of the coils. A number of cans thus filled are taken to a machine, which will be observed on the north side of the compartment of cotton machinery. Here a sufficient number of slivers are drawn by a pair of rollers from their cans, and wound side by side upon an axle, so as to form a lap; the fibres in some measure adhering to each other, and thus constituting a sheet of the material. Laps, thus formed, are taken to the other range of carding engines, and there undergo another operation of teasing and straightening; and then pass off through a conical tube, so as to be narrowed, as before, into a spongy cord. The slivers, which constitute the lap for feeding this machine, are from 30 to 40 in number; but are admitted so slowly as to be carded down to such an extent that the sliver removed from the doffer is equal to one only of the number of slivers which entered; and thus any irregularity that might have existed in a portion of the feed is so much diffused as to be nearly, if not entirely lost.

We have before spoken of the drawing-frame: the next employed is of vast importance to the cotton manufacture. This machine has since its introduction undergone great improvement, principally by the application of a "stop-motion," which arrests the action of the machine immediately as the breakage of a sliver takes place: this arrangement is applied to all the exhibited drawing frames. A number of the cans from the finishing carding engine are arranged at the back of the machine; the slivers from these pass over a series of conductors, termed "spoons," several slivers being drawn over together. These instruments are weighted guide levers, mounted so as to be capable of turning upon centres; but during the proper working of the machine are kept in a certain position by the tension of the slivers which are in process of being drawn. Upon the breakage taking place, therefore, or upon a can becoming empty, the equilibrium will be destroyed, and a part projecting from the under side of the spoon will, on the spoon falling, intercept the motion of a vibrating bar, which, being thus arrested, effects, by an arrangement of apparatus designed for the purpose, the shifting of the driving strap from the driving to the loose pulley, and thereby stops the action of the machine. To this machine the patent coiler mentioned in reference to the carding-engine is also applied, the drawn slivers being again deposited in revolving cans.

These slubbing and roving-frames next come under notice. Those exhibited by Messrs. Hibbert and Platt are three in number; the two first being distinguished by the term slubbing-frames, and the other by that of the roving-frame. The operation and arrangement of machinery, however, are substantially the same; the only object of the processes being gradually to reduce the sliver, and impart to it a sufficient amount of solidity suitable for the action of the spinning frames. This class of machines is most fully represented in the Exhibition, and the particular point to which the stream of inventive genius is now directed is distinctly shown. The beautiful mechanism of the slubbing or roving-frame appears, as far as its simplicity of construction and efficiency of working is concerned, to have arrived at a point beyond which there is but little to desire. Invention has therefore of late been directed solely to increase its quantitative producing power. The limit to this had been the velocity at which the revolving spindles and their "flyers" could be driven. In three out of the four exhibitors of cotton preparing machinery in motion, we find evidence of an earnest attention to this subject. In the series now under review, the desired end is sought to be accomplished in two ways; first, by reducing the top of the flyer so as to enable the bobbin to traverse higher than usual, and thus avoid the necessity of carrying the flyer legs so far downwards; which, being thus reduced in length, will admit of being driven at a higher speed without increasing the vibration. The second method is by placing the bevel-pinion, which drives the bobbin, upon a fixed socket instead of upon the spindle, by which method the vibration and the wear of the spindle are diminished. These improvements are said to enable the manufacturers to increase the driving speed of the

spindles one-fifth beyond the ordinary velocity attained. To the slubbing-frames of Messrs. Hibbert and Platt is attached a stop motion similar to that we have mentioned as commonly applied to the drawing-frame. The motion of the machine is therefore arrested immediately upon the breakage of a sliver. In our general description of the cotton manufacture we spoke of the sliver as proceeding direct from the leg of the flyer to the bobbin. This plan is frequently adopted, and particularly in mills where the finest yarns are spun. In those machines, however, now under review, the presser principle is adopted. On this plan, the legs of the flyers carry an arm called a "presser," which receives an inclination to move inwards by the action of a spring, so as to bear against the surface of the bobbin. The slivers pass down the legs of the flyers, and are coiled along their respective arms, threaded through eyes formed therein, and from thence are conducted to the bobbins. The action of the spring-presser is to consolidate the roving, and thereby to increase the capacity of the bobbin for holding the roving, and prevent the necessity for frequently changing the bobbin. This arrangement is distinguished as the presser bobbin; and the other as the soft bobbin.

The next in order of the machines to be noticed are those for spinning, both principles of which, viz., the mule and the throstle, are exhibited in this series; the former also being illustrated by two machines, the one for the production of welt, and the other for warp. We have already in our article *COMMON SPINNING* explained the peculiarities of these two constructions of machines, the operation of the throstle being continuous, and having its spindles mounted in a stationary frame, and the spindles of the mule being mounted on a carriage which alternately approaches to and recedes from the delivering rollers. The throstle exhibited by Messrs. Hibbert and Platt presents no features that call for particular comment; but in the mules we notice a peculiar arrangement of "scavenger" is applied. The object of this apparatus is to clear particles of waste from the top of the carriage, and the operation is effected by means of a roller, which, instead of sweeping the refuse towards the cops, moves it away in an opposite direction. The construction of these mules is on the principle of Sharp and Roberts' patent; they are provided with an adjustable cam for "backing off," and also an apparatus applied to the front roller for preventing the threads from becoming snarled.

Messrs. Fair, Curtis, and Madely, of Manchester, exhibited several preparing and spinning machines. The first of these, the carding-engine, is provided with a motion for traversing the conical tube which conducts the sliver from the doffer cylinder, and thereby causes it to be taken up by the delivering rollers at varying parts of their length; this is the patent of Messrs. Lakin and Rhode.

In the drawing-frame there is a peculiar arrangement of spoon for the stop motion; the lower part is formed as a fork; and under the space between the prongs stands out a projection from the vibrating shaft, which, when arrested in its motion, causes the stoppage of the machine. The spoons held up by the passing sliver fall vertically upon a breakage taking place, and thereby intercept the vibrating projection with one or other of their prongs, and consequently arrest the motion of the machine.

In the slubbing-frame a spring is applied to the presser, differing from those commonly employed; it being, in this instance, formed as a coiled watch-spring. This arrangement is intended to effect a more equal pressure, and a reduction in the weight of the flyer. In this machine also the tension weight, for tightening the cone-strap, is carried by a frame, which moves on a part attached to the beam, instead of allowing it to rest upon the grooved shaft; there is also an application of gearing to the shortening and traverse motions. All of the improvements are shown applied to a roving frame. Upon approaching one of these machines, the visitor is struck by the comparatively little noise made by their working; and upon inquiry, he finds that the toothed wheels, which drive the bobbins, are composed of gutta-percha; this is the patent of Messrs. Tatham and Cheatham; and if, as at present seems probable, the material should be found sufficiently lasting, a most desirable end will be accomplished by its introduction.

There are three self-acting mules, exhibited by Messrs. Fair, Curtis, and Madely. In one of these the apparatus generally adopted for producing the changes required for spinning, is substituted by an arrangement which is positive in its action; and thereby prevents the common breakages of bands, and the general injury of the machine. The cords are also prevented from rubbing against each other, and thus rendered more durable by the application of an extra scroll.

Another improvement belonging to this mule relates to the arrangement of putting down the yarn by the "faller;" the object being to prevent a coil when the "backing off" takes place; thus preventing a snarling or damage of the yarn. The "squaring shaft" is, in this machine, driven by gearing instead of bands, as usual.

Another self-acting mule exhibits an improvement upon that principle known as Smith and Orr's. The present construction dispenses with the friction or differential motion for winding on the yarn, and substitutes an application of the radial arm, arranged so as to prevent breakages of the mangle-wheel. The rollers driven inde-

pendently of the mangle-wheel, necessarily prevent a strain thereon: they may be put in motion or stopped at pleasure; and as they derive their rotation from the driving pinion, a more uniform action is obtained. This mule also is driven by one strap instead of two.

The third mule contains a new arrangement of the patented improvements of this firm, a new motion for winding on the yarn with a self-regulator being applied; the design being to enable a person, capable of "piecing ends," to superintend the machine, and reduce the making of a set of cops to as easy a task as the making a set of bobbins on a roving frame.

We next arrive at the machinery of Mr. John Mason, of Rochdale: here we find a drawing frame, with patent coiler; and also slubbing and roving-frames. The two last mentioned machines are fitted with improvements for obtaining a greater velocity in the rotation of the spindles. This consists in firmly attaching to the coping-rail, tubes, over which the bobbins pass, they being hollowed out sufficiently large for that purpose. The spindles pass through the tubes, and run in contact with the internal periphery thereof at top and bottom; by which arrangement, two bearings are obtained a considerable distance apart, affording a support productive of great steadiness of action. It is stated that, with the application of this arrangement, the spindles of roving machines, where the lift of the bobbin is six or seven inches, may make from 1,200 to 1,400 revolutions per minute. This improvement is exhibited as applied to a frame where pressers are used; and also to one arranged for the production of soft bobbins.

Another improvement in these machines is the application of a plate, situated before the delivering rollers, and through which the rovings pass on their way to the bobbins; this is for the purpose of preventing an entanglement when an end becomes broken, an inconvenience which frequently occurs in the ordinary arrangements. The perforated plates effect this by forming a shield, which keeps the broken roving from falling downwards to the other threads. To these machines an apparatus is also applied for disengaging the parts which drive the bobbins or spindles from the other parts of the machines: so that the whole series may be turned at once by hand when the bobbins are full, for the purpose of unwinding a sufficient length of each thread, for forming an attachment to the fresh bobbins.

In front of Mr. Mason's machinery will be found that of Messrs. Higgins and Sons, of Salford. The roving frame of this firm exhibits another instance of the attention paid to a gain of speed in the revolution of the spindles. According to the usual practice the spindles are formed of the same diameter throughout the upper part of their length; but in the roving-frame now spoken of, the spindles are formed of varying diameters, decreasing towards the top, which configuration admits of their being driven at a greatly increased velocity, without an extended vibration: the flyers also are so attached that the bobbin may traverse to a higher point than usual; and thus the legs are decreased in length, and consequently reduced in weight, possessing at the same time a stiffness which will bear an increased revolution. The conical pulley is mounted upon a frame which swings upon centres, so that at whatever diameter the strap may be situated it will always be distended.

In the compartment containing the machinery we have described are some cases of spindles and flyers of various constructions now in use: amongst these is one which, as it bears upon the subject of increased speed, we will particularize; this is the invention of Mr. William Maelardy, of Manchester. The object sought is here attained by causing the spindle to run in a top bearing, so as to effect a greater steadiness of action; and in order to provide for the removal of the filled bobbins, the spindle is formed in two portions which are temporarily connected together; their separation is accomplished by lifting the upper part of its top bearing; when, the lower end being turned in its bottom bearing, so as to occupy a position out of a right line, the filled bobbin may be slipped off. We are informed that these spindles are running at a considerably increased velocity.

Messrs. Sharp, Brothers, of Manchester, exhibited a throstle spinning frame on the "ring and traveller" principle. This machine is of American origin, and, although used to a considerable extent in that country, has made but little progress here. The thread, instead of passing on to the bobbin through a flyer, as in other throstles, is conducted through a fine metallic loop, mounted so as to revolve upon arms which project from the coping rail: this loop is dragged round by the traction of the thread. The bobbin does not in this case rise and fall, to distribute the yarn upon its surface, but the same effect is produced by the upward and downward motion of the ring. This machine exhibits an arrangement of friction surfaces in place of the ordinary driving toothed wheels.

In the French department was exhibited a machine called the "Epurator," the design of which is to supersede the use of the ordinary scutching machine, and effect by one operation the cleaning and carding of the material. When practice has confirmed the

use of two distinct processes, it rarely occurs that the final object can be achieved by one: all endeavours, however, to arrive at a simplification of operations should be viewed with consideration. The material to be operated upon by this machine is formed into laps, by a spreading apparatus, a number of which laps (five in the exhibited machine) are placed so as to be simultaneously fed by revolving fluted rollers to the cleaning and carding cylinder. This cylinder is 4 feet in diameter, and revolves at the rate of from 250 to 270 revolutions per minute, its periphery is provided with a series of strips of wire cards, with strong teeth, between which strips are placed flexible metallic brushes, the extremities of which project slightly beyond the surface of the cards. The grooved feeding rollers revolve slowly, and therefore present the cotton gradually to the action of the revolving cards and brushes; the effect of which is said to be the combined operation of scutching and carding, the impurities being separated by centrifugal force, and the loosened fibres laid side by side without being broken by the action of revolving beaters. Beneath each pair of feeding rollers there are gratings, through which the separated extraneous matters fall. There are three different cylinders to this machine, for the more perfect removal of the cotton; each one of which is provided with the usual doffing combs for the removal of the slivers, which are then guided so as to unite into one. The exhibitor states that this machine will produce from 220 to 260 lbs. of prepared cotton in 12 hours,—one workman superintending two or three machines; and that if coarser numbers are to be spun, a subsequent carding is unnecessary, the cotton being taken from the epurator direct to the drawing frame.

Near the machine last described will be seen a roving frame of French manufacture, in which the arrangement of wheels for driving the spindles and bobbins is different from that commonly employed in England. Instead of the two shafts, carrying their series of bevel-wheels, one only is employed, which drives a pinion mounted upon a loose collar. On the upper end of this, there is a spur-wheel, which takes into the teeth of two spur-pinions, each of which is used for driving a bobbin or spindle, as the case may be.

In the Belgian department a willow is exhibited by the Société du Phoenix, of Ghent. The peculiarity of this machine consists in the employment of a revolving shaft, provided with a series of projecting arms, arranged in a spiral form. This shaft is enclosed within a casing, the internal surface of which is provided with an iron grating. The cotton is fed in through an aperture at one end of the casing, and beaten by the spirally-arranged revolving arms, which, at the same time, carry it forward to be delivered out at the other end, the separated impurities falling through the surrounding grating.

From Belgium we have also a roving frame possessing a feature not entirely new to us, but as yet unemployed. This consists in the employment of toothed segments, of decreasing diameter, which constitute conical wheels, and are intended to displace the conical pulleys now ordinarily used; the segments are locked, one after the other, to their shafts, so as to effect the required rotation at the necessary variable speed; this invention is the subject of a patent in England granted to Messrs. Fairbairn and Hetherington.

The Exhibition does not illustrate fully the manufacture of woollen fabrics; a system of producing woollen yarns is, however, exhibited by Mr. J. Mason, of Rochdale, and claims particular attention. The machinery to which we refer has been for some years in general operation in France and Belgium; but the slowness with which an entire change of system is received in England, has prevented it from becoming as extensively employed as its merit seems to demand. In order that this machinery may be properly understood, we must, in the first place, briefly describe the usual processes employed for the production of woollen yarns, premising that our present notice refers to that branch of the manufacture relating to the class of goods technically distinguished as "woollens" in distinction to "worsted," comprising broad cloth, flannels, &c., and made from shorter descriptions of wools.

The material is first cleaned by a machine similar to the willow of the cotton manufacture, and is then subjected to the process of carding, called, in this instance, "scribbling." After this, another card operation follows, the wool being doffed therefrom, not in a continuous film, as described in reference to cotton, but in short spongy cards, equal in length to the width of the carding engine; these "cardings" are then taken to the "billy," (a machine operating upon the principle of the mule,) where they are joined one to another, generally by hand, so as to form continuous lengths, and twisted previously to being wound into cops, which are to be transferred to the spinning machine.

According to the system exhibited by Mr. Mason, the wool as it is taken by the ordinary action of the doffer comb from the first carding machine, is gathered into a narrow band, and after passing through a revolving tube, which imparts a certain amount of false twist, is wound upon a roller, so as to constitute a lap, about 16 inches in diameter, and 4 or 5 inches in breadth. When the required quantity is wound on, an arrangement of apparatus, by ringing a bell, gives notice to the attendant; immediately after which, the winding machinery, by a self-acting motion, disengages the lap;

so that a determinate quantity of material is always wound upon the roller. Several of these narrow laps are placed, side by side, upon a framework attached to a second carding machine; and their rollers are mounted so as to be capable of revolving, in order to unwind the carded wool, which unwinding is effected through the agency of surface rollers, placed in contact with the lapped material. The slivers, constituting the laps, are applied in such a number, that their aggregate width shall be equal to that of the required feed; and they are conducted through guides, so as to bring their edges together, and thus form a continuous sheet as they are fed into the second carding engine.

The wool having been carded as usual, is removed by the agency of two doffer cylinders, each of which has alternate rings of wire cards and blank places; the rings of cards on the one doffer being opposite to the spaces on the other, and *vice versa*. By this arrangement, each doffer removes a series of narrow strips of wool, which, being conducted therefrom by stripper rollers, form endless spongy cords, instead of the short cardings before referred to. These endless cords are then conducted between travelling straps, placed at right angles to the line of progress of the cords, which straps, by their rubbing action, condense the material previously to its being wound upon rollers, and sufficiently to admit of its being taken direct to the spinning machine.

It will be understood from the foregoing statement, that this system effects a great economy of labour; the feeding being self-acting, and the piecing and slubbing being dispensed with. This simplification, however, is not the only advantage; the self-feeder supplies the machine in a much more regular manner than can be attained by hand; and the "cardings" are, consequently, more even; the manufactured threads are also more "nappy," which increases the felting quality in milling, and affords a richness of appearance in the woven cloth not attained in the usual course of manufacture.

In manufacturing warps on this system, it is merely necessary to double the slivers of wool upon an intermediate engine, and draw the slubbing more in the "condenser" and mule, to obtain that straightness of fibre which gives strength to the thread. If the first process of obtaining narrow laps be repeated, so that two carding engines are fed by a number of these, a doubling, not attainable under the old system, may be effected, which will of course add to the regularity of the yarn. That this system is not universally adopted may be attributed, in great measure, to the failures which have taken place in other attempts to obtain endless cardings. Mr. Mason's machinery is now, however, employed by some of the most eminent firms of the north and west of England; and therefore may be looked upon as making its way towards that position which its merits entitle it to attain.

The French department contains an example of an endless carding machine contributed by Messrs. Merciere and Co. of Louviers; the chief distinction from that we have above described being the employment of series of revolving tubes for consolidating the cardings, instead of the travelling straps of Mr. Mason. In the "first" carding engine exhibited with this endless carding engine, the feed apron is divided into two parts, and the sliver is removed from the doffer in the same number of distinct webs, which pass through separate conical apertures, but are finally united upon the same lap roller. The object of this is to work the machine with different colours of wool, which, becoming mixed at the next operation, afford a parti-coloured carding. In connection with these machines is also a hand woollen mule; it does not, however, appear to possess any novelty which demands notice.

THEINE, the principle of tea. It may be conveniently prepared by sublimation in the apparatus of Mohr, for preparing benzoic acid, which consists of a shallow iron pan, having its mouth covered with tissue paper secured tight round the edges; and the whole then surmounted with a conical paper cap.

A decoction of the tea is precipitated by acetate of lead, the liquor filtered hot and evaporated to dryness. The dry extract is sublimed as above described.

The following proportions of theine were obtained from different kinds of tea:—

| | | | | | |
|-------------------|---|---|---|---|----------------|
| From green hyson | - | - | - | - | 1.05 per cent. |
| „ black congo | - | - | - | - | 1.02 |
| „ „ Assam | - | - | - | - | 1.37 |
| „ twankay (green) | - | - | - | - | 0.98 |

Theine was obtained from coffee by the same process slightly altered. The active properties of tea are due to this principle.

The decoction of Paraguay tea was precipitated first by acetate of lead, and then the filtered liquor by subacetate of lead; and the liquid drawn off and evaporated to dryness. When the extract was submitted to distillation, it gave long flat crystals exactly resembling theine. The sublimate also resembled theine in its odour and relations to water alcohol and ether. It also answered to the following new test of theine.

Theine is boiled for a few minutes with twice its weight of fuming nitric acid, by which a bright yellow solution is obtained. This liquid, gently evaporated to dryness, leaves a deep yellow mass. A drop of ammonia is let fall upon this, and a gentle heat applied, when a splendid purple colour is immediately produced, similar to that from uric acid.

The carbon and hydrogen in the theine of Paraguay tea were also determined: —

| | Found. | Calculated. |
|-----------|--------|-------------|
| Carbon :- | 49.96 | 49.79 |
| Hydrogen | 5.145 | 5.08 |

From want of material the nitrogen was not determined. There is no doubt that Paraguay tea contains theine, although the proportion is small.

The leaves of the *Camellia Japonica* and of the holly were examined for theine, and found to contain none. See *Txa.*

THENARD'S BLUE, or COBALT BLUE, is prepared by digesting the oxide of cobalt used in the potteries, with nitric acid, evaporating the nitrate almost to dryness, diluting it with water, and filtering, to separate some arseniate of iron, which usually precipitates. The clear liquor is to be poured into a solution of phosphate of soda, whence an insoluble phosphate of cobalt falls. This being well washed, is to be intimately mixed in its soft state with eight times its weight of well-washed gelatinous alumina, which has been obtained by pouring a solution of alum into water of ammonia in excess. The uniformly coloured paste is to be spread upon plates, dried in a stove, then bruised dry in a mortar, enclosed in a crucible, and subjected to a cherry-red heat for half an hour. On taking out the crucible, and letting it cool, the fine blue pigment is to be removed into a bottle, which is to be stoppered till used.

The arseniate of cobalt may be substituted, in the above process, for the phosphate, but it must be mixed with sixteen times its weight of the washed gelatinous alumina. The arseniate is procured by pouring the dilute nitrate of cobalt into a solution of arseniate of potassa. If nitrate of cobalt be mixed with alumina, and the mixture be treated as above described, a blue pigment will also be obtained, but paler than the preceding, showing that the colour consists essentially of alumina stained with oxide of cobalt.

THEOBROMINE; is a chemical principle found in cocoa beans, and identical with caffeine and theine as obtained from tea and coffee. It is extracted by boiling with water, filtering, precipitating with acetate of lead, filtering the precipitate after washing it, then decomposing it by sulphuretted hydrogen; or boiling it with alcohol, from which, on cooling, the theobromine separates in a crystalline powder. It is purified by re-crystallization. It is little soluble in water or alcohol.

THERMOMETER, signifies the measure of heat. Its description belongs to a treatise on chemical physics.

Philosophers have been always much troubled by the failures of the maximum self-registering thermometers, especially those exposed to the sun; the part of the tube in which the index ought to slide becomes foul, apparently lined with a coat of metal, and the index is immovable. A construction invented by Messrs. Negretti & Zambra appears likely to evade this difficulty. The mercury in its expansion is forced past an obstruction in the tube, and does not return past it in its contraction. No index is required in this construction. "The specimens of this instrument which we have tried answer well," says the Astronomer Royal.

In the Quarterly Report of the Registrar General, there is the following annotation: —

"The form of instrument adopted during the past quarter for maximum temperature is that of Negretti & Zambra, which is found to act admirably."

Its construction is as follows: a small piece of glass is inserted near the bulb and within the tube, which it nearly fills; — on an increase of temperature, the mercury passes this piece of glass, but on a decrease of heat, not being able to re-pass it, remains in the tube, and thus indicates the maximum temperature. After reading, it is easily adjusted.

Directions for using Negretti & Zambra's Self-Registering Maximum Thermometer. — For determination of the maximum temperature of the air. — Suspend the thermometer by means of the two brass plates attached for that purpose, in such manner that the bulb is a little lower than the other part of the instrument, and so placed that it is in the shade, with the air passing freely to it from all sides: then on an increase of heat, the mercury will pass up the tube as in an ordinary thermometer, and continue doing so as long as the heat increases.

On a decrease of heat, the contraction of mercury will take place below the bend in the tube, leaving the whole column of mercury in the tube, thus registering the highest temperature, and showing such till the instrument is disturbed.

To prepare the instrument for future observation, it is simply necessary to remove

that end from its hook which is the farthest from the bulb ; to raise it, till the instrument is nearly perpendicular ; and then to slightly agitate it while the brass plate the nearest to the bulb is still suspended from its hook. The mercury will descend in the tube, and indicate the temperature of the air at that time, and when again suspended from its hook, is prepared for future observation.

For determination of the solar radiation.—The instrument for this purpose must have a black bulb ; it should be placed nearly horizontal, with its bulb in the fall rays of the sun, and if possible, so that lateral wind should not strike the bulb. The directions for use are identical with that for the determination of the temperature of the air.

THERMOMETER, SELF-REGISTERING, by Mr. Brooke. The Exhibition contained a wet and dry bulb thermometer, and apparatus for registering the temperature they indicate. The registering apparatus consists of a pair of vertical concentric cylinders, supported on a table. The bulbs of the thermometers are underneath the table, through which the stems pass vertically, and are placed between the opposite sides of the cylinders and two lights. A narrow vertical line of light brought to a focus by a cylindrical lens falls on the stem of the thermometer, and passing through the empty portion of the bore affects the paper. The boundary between the darkened and undarkened portion indicates the position of the mercury in the stem of the thermometer. Fine wires are placed across the slit in the frame, through which the light falls on the stem. They intercept narrow portions of the light, and thus the scale of the thermometer is continuously impressed on the register, as well as the temperature. *a, b, fig. 1447.*, are camphine lamps ; *c, d*, cylindrical lenses, by which a bright focal line of light is obtained ; *e*, the psychrometer, or wet bulb thermometer ; *f*, the dry bulb thermometer ; *g*, two concentric cylinders, between which the photographic paper is placed ; *h*, the register, as it appears after the impression is developed ; *i*, one of the rollers of a turn-table, on which the cylinders rest ; *j*, the frame which contains the time-piece ; *k*, a bent pin, or carrier, attached to the axis of the cylinders ; this is carried round by a fork at the end of the hour hand of the time-piece. As this apparatus is necessarily placed in the open air, when in actual operation it is provided with, 1, an inner cylindrical zinc case, with sliding doors, to protect the sensitive paper from light, when the cylinder is removed from, and brought back to the photographic room ; 2, an outer wind and water-tight zinc case, with water-tight doors for removing and replacing the cylinders, and for trimming the lamps, if lamps are used.



The skilful application of photography by Mr. Brooke to register natural phenomena, with no more labour than that of supplying the cylinder punctually with prepared paper, is one of the most useful and beautiful uses to which photography has as yet been applied. The paper is prepared so as to render it extremely sensitive to light, being first washed with a solution of isinglass, bromide of potassium and iodide of potassium, in the proportion of 1, 3, and 2, respectively ; and when required for use, it is washed with an aqueous solution of nitrate of silver, which causes the paper to be sufficiently sensitive to the action of light, so that if a beam of light be allowed to fall upon it, an impression is made upon that part where the light falls, which becomes visible on being washed with a solution of gallic acid, with a small admixture of acetic acid. A light is placed near a small aperture, through which rays pass and fall upon a concave mirror carried by a part of the suspension apparatus of the magnet, and this reflection falls upon a plano-cylindrical lens of glass placed at the distance of its focal length from the paper on the cylinder. As the magnet is ever varying and making small excursions on one or other side of its mean position, the point of light traces a corresponding zigzag on the paper. The thermometer apparatus has no mirror and no reflector, the mercury in the tubes themselves intercepting the pencils of light ; and thus this apparatus, throughout the day and night, is constantly recording the slightest change of position of the magnets and the smallest changes of temperature.

The object of this self-registering magnetometer above described is to determine the

direction and intensity of the earth's magnetism. Its direction is generally found by suspending a piece of steel previously magnetized, or in other words a magnet, by parallel threads of untwisted silk, and the bar settles in that position in which magnetism causes it to rest, and which is called the magnetic meridian. The angle between the astronomical meridian and the magnetic meridian gives the magnetic declination which is the subject of research with the declination magnetometer; at present, this value in London is about $22\frac{1}{2}^{\circ}$ west of the astronomical meridian.

Having determined the declination, the vertical plane is determined in which the force of magnetism is exerted.

The angle which the magnet makes when freely suspended on this plane from the horizon is termed the dip. At present the dip at London is about $68^{\circ} 40'$. The force of magnetism exerted in this inclined direction can be resolved into two forces, the one acting in a horizontal direction, the other in a vertical direction, so that conjointly they shall produce exactly the same force as the single force. The biplanar, or horizontal force magnetometer is intended for measuring the variations of the horizontal component of the variations of the force of magnetism. It consists of a magnet suspended by two halves of a skein of untwisted silk, kept at a certain distance apart. If an unmagnetized bar were thus suspended, it would remain at rest only in that position in which the two parts of the suspension skein were without twist, and if it were turned out of this position, it would endeavour to resume its former position with a force proportionate to its weight, and the angle through which it had been turned. This principle is made the means of measuring the force of magnetism. A freely suspended magnet always endeavours to rest in the magnetic meridian.

The variations in the vertical component of the magnetic dip are the subjects of investigation with the vertical force magnet, which is a magnet placed nearly at right angles to the magnetic meridian. It is kept horizontal, or nearly so, by weights balanced with extreme accuracy, and made to vibrate like a balance; and from its different inclination the variation of the vertical force of magnetism is determined.

Thermometrical Table, by Alfred S. Taylor, Esq.—The accompanying thermometrical table of Mr. A. Taylor has been copied from a thermometer in his possession, graduated on the scales of Fahrenheit and Celsius. It has been designed to obviate the necessity for those perplexing calculations, so often rendered necessary by the use of different methods of graduation in England and on the continent. In most chemical works, we find, besides the rules given for the conversion of the degrees of one scale into those of another, comparative tables, which, however, convey no information beyond the bare fact of the correspondence of certain degrees. In this table, the attempt has been made to make it convey information on numerous interesting points, connected with temperature in relation to climatology, physical geography, chemistry, and physiology.

There is another advantage which a table of this kind must possess over those hitherto published in works on chemistry. In the latter, the degrees on one scale only run in arithmetical progression, while the corresponding degrees on the other scale, are necessarily given in fractional or decimal parts, and at unequal intervals. Thus, in some of the best works on chemistry, a comparative table is printed, which is only fitted for the conversion of the Centigrade into Fahrenheit degrees, so that a person wishing to convert the Fahrenheit into Centigrade degrees, would have to revert to one of the old formulæ of conversion. This process must also be adopted whenever the Centigrade degrees are given in decimal parts, for all the tables yet published in English works, wrongly assume that the Centigrade degrees are always given in whole numbers. The present table renders such calculations unnecessary, since the value of any degree, or of any part of a degree on one scale, is immediately found on the other, by looking at the degree in a parallel line with it. The main divisions will, I believe, be found perfectly accurate:—in single degrees a little inequality may be occasionally detected; but I have not found the error to be such as to affect the calculated temperature.

Although the Fahrenheit and Centigrade scales are the two which are chiefly used in Europe, it has been thought advisable to carry out the parallel degrees of Réaumur's scale, by dots on the drawing of the tube. This table, therefore, comprises in itself six distinct tables, assuming the necessity for each scale to be represented in whole degrees,—with the additional advantages: 1st, that the space occupied is smaller, and 2nd, the value of any fractional part of a degree on one may be at once determined on the other two scales.

It is extraordinary, considering the great advances which have been recently made in physical science, and in the manufacture of philosophical instruments, that the makers of thermometers should still adhere to the old and absurd practice of marking on the Fahrenheit scale, the unmeaning words Temperate, Summer-heat, Blood-heat, Fever-heat, Spirits boil, &c., when the instrument might be easily made to convey a large amount of information, in respect to climate, as it is dependent on temperature. Thus the mean temperatures of England, Ireland, and Scotland, with the maxima and minima, as

CENTIGRADE.

REAUMUR.

FAHRENHEIT.

| CENTIGRADE. | REAUMUR. | FAHRENHEIT. |
|---|----------|---|
| Chlor. Cyanogen vol. | 190 | pr. steam, 19 at. |
| Tin and lead, p. s. m.; also Alloy 18 T. 4 L. (Plumbers' solder). | | 372 Zinc pulverisable. |
| Sat. sol. Chloride zinc boils. | | Arsenious acid vol.; Sulphurous acid b. |
| | | Dichlor. carbon, b. & v. 47. |
| | | pr. steam, 11 at. |
| | | Fulminating mercury explodes. |
| Alloy 4 T. 1 L. m. | | Alloy 15 T. 4 L. m. |
| Oxalic ether, b. 1°38. | | |
| Sulphuric acid, 1°67 boils. | 352 | Alloy 14 T. 4 L. m. |
| pr. steam, 10 at. | | Elast. Turp. V. 60°3. |
| | | Alloy 13 T. 4 L. m. |
| Parasulphathaline, m., alloy 13 T. 4 L. melts. | 180 | Arsenic vol.; sugar melts; hydruret of benzamide m. |
| Oil of oranges, b. 0°323. | | Succinic acid melts. |
| Starch converted to dextrine. | | Alloy 5 B. 23 L. 24 T. m.; Citronene b. 0°323. |
| pr. steam, 9 at. | 352 | Alloys 5 T. 4 L. and 11 T. 4 L. m. |
| Elast. Turp., v. 26°3. Sulphuric acid 1°63 boils. | | Sulphuret solid; iodine boils, d. v. 0°323. |
| Alloy 10 T. 4 L. m. | 140 | Malic acid m. |
| | | Alloy 5 B. 23 L. 26 T. m. |
| | | |
| Alloy 9 T. 4 L. m. | | Oil of lemons boils, 0°348. |
| pr. steam, 8 at. | | Oil of Cascadilla b. 0°323. |
| Alloy 8 T. 4 L. m. | 170 | Alloy 5 B. 30 L. 24 T. m. |
| Alloy 7 T. 4 L. m. | | Caoutchoucine boils. |
| pr. steam, 7°3 at. | | Elast. Turp. V. 47°3. |
| Alloy 1 B. 2 T. m. | | |
| | | Sat. acct. potash boils; eugen b. |
| pr. steam, 7 at. | | Alloy 6 T. 4 L. m.; |
| Alloy 6 B. 23 L. 24 T. m. | 332 | Alloy 5 B. 23 L. 26 T. m. |
| Oil elemi, b. 0°323. | | Oxalic acid vol.; elast. turp. V. 47°1 |
| | | Alloy 5 B. 23 L. 30 T. m. |
| pr. steam, 6°3 at. | 150 | |
| | | Alloy 5 B. 23 L. 40 T. m. |
| Elast., A. V. 127°32. | 322 | Alloy 5 B. 23 L. 26 T. m. |
| pr. steam, 6 at. Fusible. Alloy 5 B. 23 L. 24 T. m. | | Naphtha boils; alloy 9 B. 23 L. 24 T. m., also 5 B. 23 L. 27 |
| Alloy 5 B. 23 L. 24 T. m. | 160 | Prussian blue decomposed. |
| Elast. A. V. 131°57. | | Alloy 5 B. 16 L. 24 T. m. |
| Fulminating silver explodes. | | Oil of turpentine boils 0°32; dens. V. 47. |
| pr. steam, 5°5 at. | | Alloy 5 B. 16 L. 23 T. m. |
| Elast. A. V. 125°32. | 312 | Quinine m. |
| Elast. Turp. v. 26°4. | | Alloy 5 B. 20 L. 24 T. m.; oil juniper b. |
| pr. steam, 5 at. | | Alloy 5 B. 23 L. 24 T. m. |
| Elast. A. V. 120°03. | | Sect. petroleum b. |
| | | Carb. pot. sat. boils. { Alloys 5 B. 16 L. 16 T. |
| Elast. Turp. v. 26. Sat. nit. Hme boils. | 150 | { and 5 B. 16 L. 20 T. m. |
| Sulphur burns feebly. | 120 | 302 ETHERIFICATION ends; latent heat; ether vap. |
| Elast. A. V. 114°15. | | Alloy 5 B. 16 L. 2 T. m.; camphirene b. 22.; sugar of milk m. |
| Turbomide Siliceo, b. | | Asphaltum melts; camphor melts, d. v. 5°31. |
| pr. steam, 4°3 at. | | Minc malleable. |
| Mastic resin, m. | | Alloy 5 B. 16 L. 12 T. m. |
| Alloy 5 B. 16 L. 18 T. m. | 292 | Alloy 5 B. 16 L. 16 T. m. |
| Elast. A. V. 108°31; Temp. of certain factories. | | Gypsum converted to plaster. |
| Nicotine distils. | | Sulphuric acid, 1°22 b. |
| pr. steam, 4 at. | | |
| Elast. A. V. 102°45. | | Elast. A. V. 96°64. |
| Fulminating gold explodes. | | Tin and bismuth, p. s. melt; succ. acid vol. |
| Alloy 5 B. 16 L. 14 T. m. | 140 | pr. steam locomotive boilers. |
| | | 282 ETHERIFICATION begins. |
| Chlor. cyanogen, m.; S. G. 1°33. | | |
| Grape sugar to Caramel. | | |
| Elast. A. V. 90°36. | | |
| | | |
| Sat. nit. ammonia boils. | | Cholesterine melts. |
| | | Elast. A. V. 85°47. |
| pr. steam, 3 at. | | Oil black mustard b.; maleic acid m. |
| Pimelic acid, m.; Elast. A. V. 79°94. | 272 | Prucyl b. 0°32. |

CENTIGRADE.

REAUMUR.

FAHRENHEIT.

Chloride benzoic, m.

Phloridzine solid. Alloy 8 B. 10 L. 8 T. m. 130

Camphoric acid v. pr. steam, 75° f. Elast. A. V. 69° 72.

Sebacic acid m.; Elast. alch. v. 165° f.

Sat. mur. ammonia boils.

Sat. acct. soda boils.

Pyromeconic acid m. Elast. A. V. 60° 63. pr. steam, 2 at. Sat. nit. soda boils.

Cinnamic acid m. caoutchouc melts. 120

Alloy 8 B. 1 L. 4 T. m.

Sat. chlor. strontium boils. Elast. A. V. 51° 54.

Syrup boils 86 per cent.; chlor. calcium sat. boils. Elast. A. V. 47° 2. Alloy 8 B. 8 L. 4 T. m.

Chloric ether, 1,227 boils; pr. steam, 1° 5 at.

Elast. A. V. 43° 34.

Elaene b.; Elast. alch. v. 84° 1, 110 Phloridzine m. Elast. A. V. 39° 59.

Alloy, 8 B. 8 L. 3 T. m.

Oxalhydic acid, b. 1375. Water of the Dead Sea boils. Sat. carb. soda, chlor. of barium, and chlorate potash boil: Balaicne m.; nitric acid, 1° 16 b.

Mur. acid, 1° 136 b.

Syrup boils 43 per cent. sugar.

Chlor. alumina boils; water boils, bar. 31° 37 f. Glauber salt sat. boils.

c. l. 1 pt. ice; 4 sulphuric acid; pr. steam, 1 at. Elast. A. V. = 30 S. G. 634.] Water boils bar. 23 in. Perox. chlor. explodes. W. B. MADRID.

W. B. EL SATTRE (between Dead Sea and Akabah.) COMAGILLAS. Mexican Springs.

W. B. GAVARNIE PYRENEES. Volcanic mud; JORULLO, S. AMERICA. Oxychlorocarbonic ether b. Elast. ether vap. 166; Elast. A. V. 25° 54. W. B. MEXICO. 7471 ft. el.

W. B. SANTA FE DE BOGOTA. 8730 ft. el.

Water boils; CONVENT ST. BERNARD. 9734 ft. el.

W. B. FARM OF ANTISANA Andes, 13,000 ft. el.

Chloric ether b. 1° 94. W. B. source of Orus, CENTRAL ASIA. (13,000 ft. elev.)

Elast. A. V. 15° 15.

Geyser Springs, Iceland. Elast. A. V. 14° 2.

Heat of fluid. bees wax. Elast. alch. vap. 30 in. S. G. 0° 213.

Syrup sat. boils. Corrosive sublimate volatilized.

Elast. A. V. 74° 79. Margaritic acid; castor oil m. Elast. alch. V. 165° 1. Syrup boils 89 per cent. sugar. 262 Sat. tartrate potass boils.

Sat. nitrate potass boils; heat borne by Sir J. Banks and Dr. Blagden. Hydriodic acid boils 1° 7; also hydrobrom. acid, 1° 6. Elast. A. V. 64° 54; pimaric acid m.

Alloy 8 B. 8 L. 6 T. m.

252 Nitric acid 1° 42 boils.

Elast. alch. V. 132° 3; dichl. carbon v.

Benzine melts; hyd. acct. acid boils (Turner). Elast. A. V. 55° 34.

Heavy muriatic ether b. Elast. alch. V. 118° 2.

342 Alloy 8 B. 8 L. 6 T. m.

Sulphuric acid 1° 30 b.; pyrogallic acid m.

Veratring and benzamide m. Accumulated temp. of air, EDINBURGH. Acet. acid 1° 063 boils; nit. acid 1° 30 b.

Syrup boils 84 per cent. sugar.

328

Sulphur melts, d. v. 6° 56; benzoic m.

Benzoic acid melts, d. v. 4° 37.

Balaicne m.

Zinc malleable; heat borne by Delacroche.

Sat. chlor. sod. boils.

Sat. chlor. pot. boils.

223

Sat. phos. soda boils.

Muriatic acid 1° 947 b. Elast. A. V. 86° 25.

Accumulated temp. of air, GENEVA.

Asphaltum soft; iodine melts; elast. ether V. 240.

Elast. A. V. 33° 49 inches mercury; grape sugar m.

Oemic acid volatilized. Silylic acid m.

Water boils 1054 ft. dep.; selenium melts; water boils, bar. 31.

Water boils, 328 dep.; W. B. DEAD SEA and SEA of TIBET. [BLAS.

Water boils, 300 ft. bar. 30.

Water boils 531 ft. elevation.

Water boils 1064 ft. elevation; oemic acid melts.

Water boils 1690 ft. elevation; Beldievik spr.

Water boils 2128 ft. elevation.

Water boils 2678 ft. elevation; alloy 8 B. 8 L. 3 T. m.

Water boils 3221 ft. elevation.

Water boils 3766 ft. elevation.

Water boils 4313 ft. elevation.

Water boils 4863 ft. elevation.

202

Water boils 5413 ft. elevation.

Fusible metal, 8 B. 8 L. 3 T. m.; chloral b. d. v. 5.

Elast. alch. vaps. 54.

W. B. St. Gothard, 8697 ft. elevation.

W. B. Mt. William, AUSTRALIA, 9300 ft. el.

Water boils at Quito, 9241 ft. el.

Sodium melts; Truckers springs S. AMERICA.

192

Water boils summit of Etne, 10,246 ft. elev.

Elast. ether vap. 184° 8; alch. vap. 43° 2.

Alcohol b. 0° 967, 25 per cent.

Nitric acid 1° 422 boils; alcohol b. 0° 956, 30 pr. c.

Ozookerite m.

182

Water boils Mont Blanc summit, 15,630 ft. el.

San Germano bath, NAPLES.

Starch dissolves; alch. b. 0° 878, 71 per cent.

AIX LA CHAPPELLE, spr. max. t.

Latent heat, petroleum vap., also oil turp.

80

Alcohol boils, 0° 835, 86 per cent.

Thermal spr., J. LUCON.

Alcohol boils, 0° 794, also 0° 812, 94 per cent. to 100.

Naphthaline melts.

173

CENTIGRADE

REAU MUR.

FAHRENHEIT.

Pitch melts.

Vapour bath, FINLAND, max. t.

Perchlor. carbon vap. 1°55.

Helenine m.

Elast. A. V. 9°46; ether vap. 80°3

Starch converted to sugar.

Baden Baden Springs, max. t.

CALPEE, INDIES, max. t.
BAGNERES DE LUGHON, spr.

Elast. A. V. 7°42, S. G. 0°17; ether, vap. 67°4.

Albumen opaline.

Elast. A. V. 5°37.

Heat of fluidity Spermaceti.

Heat of fluidity sulphur.

Vapour bath, RUSSIA.

Chloroform, b. d. v. 4°2.

Nitric acid (1'5) 50 pts. water, 12 pts. from 60°.

Mariana springs, S. AMERICA.

Elast. ether, vap. 61°9.

BARBARY max. t.

Abietic acid m.

Ammonia 0°286 b.

Elast. A. V. 4°2.

OASIS OF MOORZOUK, max. t.

FEZZAN, AFRICA, max. t.

Terchlor. silicon, b.

BAGNERES DE BIGORRE, spr.

Amalgam 5 B. 5 L. 3 T. and 3 mercury m.

Concent. sulphuric acid evaporates.

Palmitic acid m.

Hamman All springs. BARBARY.
PAMPAS, SOUTH AMERICA.

CENTRAL AFRICA, s. t.; BASSORA, max. t.

PONDICHERY max. t.

Chloronaphthalene m.

PHILOE, EGYPT, CAPE OF GOOD HOPE, max. t.

Myrtle wax m.

SENEGAL, s. t.

BAREGE, spr. t.

MADRAS, CAIRO, max. t.

Ournartok spring, GREENLAND.

GUADALOUPE, max. t.

PARIS 1793, EQUATOR, max. t.

Euphon b°0'6.

GUANAXUATO MINES, 1700 ft. deep, 7034 ft. el.

MEXICAN MINES, max. t.

STRASBURG, VIENNA, s. t. *Man. min. t.

TEXAS, s. t.

MARTINIQUE, max. t.

STOCKHOLM, max. t.

COUNSEL MINES, CORN WALL, 1740 ft.

COPENHAGEN, WARSAW, max. t.

EAUX BONNES, Pyrenees,

max. t. of SURINAM.

BOCHAT, spr.

CAIRO, A. T.

IS. MALTA, EGYPT, m. s. t.

FONDICHERY, m. t.

Schlangenhad Spa.

CUMANA, m. t.

BRAZILS, m. t.; BARBARY m. s. t.

CEYLON, SENEGAL, BATAVIA, m. t.

MADRAS, m. t.

CONGO, MANILLA, BENARES, HAVANNAH, m. t.

BOMBAY, m. t.; ITALY, m. s. t. Date tree, VERA CRUZ.

Artesian well (300 ft.), BRAZILS, JAMAICA, m. t.

RIO JANEIRO, m. t.

CANTON, MACAO, m. t.

BAGDAD, m. t.

Aldehyde, b.; CARACAS, CAIRO, m. t.

Elast. ether vap. 27°6, alch. b. 33 per cent. 6°817.

Elast. A. V. 11°5.

Phosphorus burns violently; acetic ether b.
Oil of cedar melts, Carlsbad Spa.

Elast. A. V. 10°4.

Heat of fluidity lead.

Albumen coagul.; acetic ether boils; Pisciarelli springs.
[NAPLES.]

Kochbrunnen, Wiesbaden.

Stearic acid melts.

Elast. A. V. 5°4.

STEAM BOATS ENGINE ROOM, W. INDIES.

HECLA, EARTH AT SUMMIT

Thermal spr., TAJURAH AND SHOA.

White wax melts; pyrox. spirit boils.

Wiesbaden Spa; hydriod. ether b., S. G. 1°33.

Plombieres spr.

Ambergis m.

Ichia springs, NAPLES; Lenker spr. 5000 ft. el.

Aix-la-Chapelle Spa.

Yellow wax melts.

Ammonia 0°94 boils; pyroxylic sp. b. 0°233; elast. A. V. 57°4.

Muriatic acid 1°19 boils.

UPPER EGYPT, in a tent; Arles spr.

Elast. A. V. 5°14.

Margoric acid melts.

Formic ether b., S. G. 91a.

Acetone boils (pyroacetic spirit).

Oleum boils.

Fossasium melts; vapour bath ends.

Berger in vapour bath 12 min.

Jorullo springs, S. AMERICA; MYNPOOREE, max. t.

Banda 3, Fernando, S. AMERICA, air 101°.

Stearic and oleic acids (mixed) melt, BELBEIS, EGYPT.

Mutton suet melts; Cauterets spr.

Katakakanum spr.

122 Styrcaine m.

Stearine and cetine melt; myristic acid m.; elast. A. V. 53°.

Palmitic acid m.

Bath springs, max. t.; supposed depth 3,350 ft. *Lark.

Bromine boils; hot pump at Bath, dens. Br. V. 5°54.

Ems Spr. max. t.

King's bath at Bath; laurine m.

Sol. ammonia boils 0°91.

112 Spermaceti melts; Muscat springs.

*Duck, *guinea fowl, raven.

*Pigeon; PEKIN, max. t.; Vichy spr. max. t.

C. fow!; Cross bath at Bath.

Birds, 106°; 111°.

Sulph. carbon boils.

Cold blooded animals die.

Temp. for incubation; elast ether vap. 30 inches.

*Sheep and pig, owl; phosphorus melts.

*Ape, dog, goat; artificial incubation.

102 *Squirrel, rat, cat, jackal, panther.

*Bat, hare, tiger, horse, elephant; elast. A. V. 1°36.

Warm bath ends, vapour bath commences.

*Temp. man, kite (birds).

Blood heat, hedgehog, dormouse.

*Teplid bath ends, warm bath begins.

*Ether boils 0°734; dens. V. 2°36.

99 OIL OF ROSES melts; acetic acid m.

PUTREFACTION rapid. Old palm oil m.

VALENCIANA MINE, MEXICO; Grenelle well, 1,794 ft.

Elast. A. V. 1°36; Faldice mine.

Tallow melts.

ACTIVOUS FERMENTATION.

PETERSBURG, max. t.; oil nutmeg m.

Kaisereyeh, ASIA MINOR, 4,300 ft. el.

*Tortoise, Cornish mines, Buxton Spa, DALCOATH MINE [1,628 ft.]

*Serpents, SEA EQUATOR, 32°7.

82 Nitrous acid 1°42 boils; Buxton bath, ALGIERS, s. t.

EQUATOR, m. t. 81°5; *oyster, snail, (Tropics).

Phosphorus luminous in pure oxygen; NAPLES, s. t.

Prussic acid boils 0°69.

Frog, shark, flying fish, scorpion (Tropics). [Tel. A. V. 1.]

Insects, silk worms hatched, germination.

Bristol Spa, temp., wasp.

MEXICAN MINES, 1,500 ft. deep.; SYDNEY, s. t.

Glow worms, crickets, RUSSIAN MINES, 580 ft.

Artesian well, GRENELLE, 1,300 ft. deep.

72 MONKWEARMOUTH, MINE, 1,500 ft. deep.

CENTIGRADE.

REAUMUR.

FAHRENHEIT.

SANTA CRUZ, TENERIFFE,
Hypon. ether b.; iodine vaporized.
Elast. A. V. 0.731.
Cotton tree; **ALGIERS,** m. t.
Olive land, **AUSTRALIA, MALTA,** m. t.
CAPE OF GOOD HOPE, FUNCHAL, m. t.
Elast. A. V. 0.616.
Cultivation of vine ends.
ENGLAND, m. s. t. 62°

TOULON, m. t.
Elast. A. V. 0.52; **ROME, NICE,** m. t.
ELVILLE, I. (max. t.) NISMES, GENOA, LUCCA, m. t.
PERPIGNAN, MON PELLIER, m. t.
Waterford mines, 74 ft. dep. **MARSEILLES,** m. t.
LISBON, BOLOGNA, BORDEAUX, AIX, VENICE, m. t.
LYONS, VERONA, MILAN, m. t.
PAU m. t. **LOWE'S EGYPT, w. t.**
AMSTERDAM, PEKIN, NEW YORK, m. t.
m. t. **NANTES, ST. MALO,**
MALTA, w. t.; m. t. **BRUSSELS,**
PENZANCE, m. t.
Cultivation of vine begins, **PARIS, LONDON,** m. t.
Elast. A. V. 0.37. S. G. 0.1.

Salt mines CRACOW, 730 ft.; Muriatic acid, 40 at. Liq. }
Sulphur. hyd. 17 at; ammonia, 65 at }
EDINBURGH, BELLIN, DUBLIN, m. t.
INVERNESS, COPENHAGEN, m. t.
COVE CORK, w. t., m. t. TORONTO,
MONT PERDU, PYRENEES, 11,265 ft. el.
UPSAL, STOCKHOLM, QUEBEC, m. t.
CANADA, m. t. Elast. A. V. 0.253.
CHRISTIANIA, DRONTHEIM, m. t.
Hybernation of animals.
PETERSBURG, m. t.; Etia sum. 10,505 ft. el.
KASAN, m. t.
POLAR SEA S 300 ft. deep.
BERGEN, PADUA, COLUMBIA, r. w. t.
MOSCOW, m. t.; oils freeze. **ALTEN, NORWAY, m. t.**
Carbonic acid liq. 36 at., N. CAPE LAPLAND, LABRADOR,
Elast. A. V. 0.2 inches; S. G. 0.03.
CUMBERLAND, HO. N. A. t.
Earth, **YAKUTSK, 350 to 382 ft. dep.**
CHIMBORAZO, 18,500 ft. el.

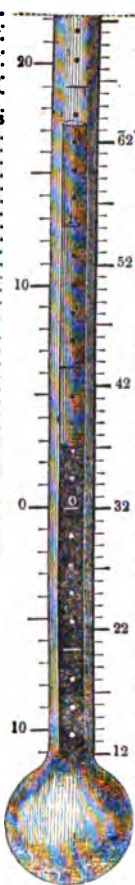
MONT BLANC, 15,000 ft.
HIMALAYAS, 15,000 ft. el.
IRKUTSK, m. t.
SIBERIA, m. t.
Earth YAKUTSK, 77 ft. dep.
AIR m. t. POLAR SEA.
NOVA ZEMBLA, m. t., PORT ENTERPRIZE, w. t.
Anhyd. sulphurous acid boils.
Oil of turpentine freezes.

Lowest natural temperature at **YAKUTSK** in Siberia,
—72°=94° below this scale.

CENTIGRADE TO FAHRENHEIT.

Above Ice. Between Ice and Zero.
Cx 1.8 + 32. 32 (Cx 1.8)

Below Zero.
Cx 1.8 - 32



Water boils in vacuo, *crab.
VINOUS FERMENTATION, butyrim melts, CAIRO WELL,
DURHAM COAL MINES, 500 ft. (210 ft. deep.
Coosa nut oil liquid, Matlock bath, Grotto del Cane.
CORDILLERAS, ANDES, m. t. 3,500 ft. el.
Matlock springs, **CUMBERLAND COAL MINES, 600 ft.**
SAXON MINES, 1,346 ft.; Bakewell springs. (der.
MADEIRA, m. w. t.; air centre of Atl. waters of the Scaman-
INAPLES, m. t. Temp. for sick rooms.
DEEP MINES, EUROPE; sea bank of Aquillas.
PARAMATTA, N. S. W. m. t.; **ALGIERS, w. t.;** sea Azores.
Fluoric acid boils, anhyd. chlorine liq. 4 at.
Acetic acid cryst.; Pray de Idome, 3,600 ft.
CAIRO w. t., MINES OF BRITANY 500 ft., BERGEN s. t.
*Trout, **MEDITERRANEAN SEA 2,900 ft. deep.**
Vaucluse fountain, 360 ft. el.
Artesian well **VIENNA, 200 ft.;** Hanwell, 290 ft.
Camphor floats, elast. A. V. 0.14.
PIC DU MIDI, 5,660 ft.; **JERSEY, m. t.**
Oil of aniseed solid, muriatic ether boils.
CLERMONT, m. t.; Columbia r. m. t. (begin.
ITALY, m. w. t.; **VIENNA, m. t. 505;** **PUTREFACTION**
Liq. amur; boils, Sat. at. 32; **STRASBURG, m. t.**
WARSAW, BERNE, m. t. **PRAGUE, GENEVA, m. t.**
TENERIFFE PEAK, 15,072 ft. el.
ZURICH, GOTTINGEN, LABRADOR s. t.
Sulphurous acid liq. 2 at.; protox. nit. 50 at.; Cyanogen, 30 at.
SEA EQUATOR, 3,400 ft. deep.
DEEP SEA, com-mon springs, HASTINGS, w. t.
LAKE OF GENEVA, 1,000 ft. deep; **ROME, w. t.**
LAKE LUCERNE, 650 ft. deep; *beetle, **PAU, w. t.**
St. acid freezes; **CARPETH MOUNTAINS;** mercury evap.
CAPE HORN SEA, SURFACE OF SEA, max. density of water.
EDINBURGH, w. t. ENGLAND, m. w. t. 37 s. (w. t.
Alcohol boils in vacuo; **NOVA ZEMBLA s. t. SHELTLAND**
Fixed oils freeze; **SOUTH SEA, 12,420 ft. deep.**
CAPE HORN SEA, 5,400 ft. deep.
Mount Argæus, ASIA MINOR, 10,300 ft. el.
ICE, chlor. wr. freezes, ac. 3rd., hydr. freezes.
POLAR SEA, 2,300 ft. deep; earth **YAKUTSK, 282 ft. deep.**
Milk freezes.
CARTHAGENA, SPAIN, w. t.
Salt water freezes, 1,026; vinegar freezes; formic acid freezes.
Earth YAKUTSK, 217 ft. deep.
JUNGFRAU, summit, 12,725 ft.
Blood freezes, earth **YAKUTSK, 119 ft. deep.**
Elaïn freezes, **HECLA (Air) at summit, 5,110 ft. el.**
Oil bergamot freezes.
Oil cinnamon freezes, oleic acid (castor oil) freezes.
Wine freezes.
Earth YAKUTSK, 50 ft. dep.
GULF BOTHNIA AIR, m. w. t.; Great Bear Lake, m. t.
AIR 23,000 feet elevation above PARIS (at surface 87°.)
Salt water freezes, 1°104.
RUSSIA, m. w. t.
Prussic acid cryst. 0.69 S. G.
ALTEN, NORWAY, w. t.
N. POLE, m. t. 13 b. low zero (calc.)
Mercury freezes, 1.40° below zero, m. w. t. at **NOVA**
Ether boils in vacuo. } **ZEMBLA AND YAKUTSK.**
Carbonic acid freezes 118° below zero.
Lowest artificial cold 187° below zero.

FAHRENHEIT TO CENTIGRADE.

Above Ice. Between Ice and Zero.
F - 32 32 - F
1.8 1.8

Below Zero.
F + 32
1.8

ABBREVIATIONS.

m. melts. m. t. mean temperature. w. winter. s. summer. at. atmosphere. b. boils. v. volatilized. liq. liquid. liq. liquid. Ad. acid. max. maximum. min. minimum. Sol. solution. W. B. water boils. el. elevation. In reference to fusible alloys. B. Bismuth. T. tin. L. lead. pr. pressure. dep. depression. I. Island. Vap. Vapour. Elast. Elasticity. Fluid. Fluidity. Alc. Alcohol. Turp. Turpentine. dens. density. In regard to places mean temp. is implied where not expressly stated. r. river. spr. spring. fr. freezes. A. V. Aqueous vapour. d. v. density of vapour. S. G. specific gravity. The Elasticity of Vapours is given in inches of Mercury.

TEMPERATURES ABOVE THE SCALE.

Tin and Cadmium m. 442°. Tempered Steel (straw color) 460°. Sc. ad. 178 b. 467°. Bismuth m. 470°. Tempered steel (brown) 500°. Fixed Oils b. 530°. Tempered Steel (red and purple) 550°. The same (blue) 600°. Lead m. 612°. Sc. ad. 185 b. 648°. Mercury b. 685°. Zinc m. 680°. Gunpowder explodes 700°. Antimony m. 810°. Red heat 900°. Flint glass m. 1000°. Heat of common fire 1141°. Brass m. 1869°. Silver m. 1873°. Copper m. 1900°. Gold m. 3010°. Cast Iron 2780°. Pure Iron and Platina m. 3200°. Wind furnace white heat 3300°.

well as the mean range of the thermometer throughout the year, might easily find a place on all the common scales. When the length of the scale would admit of such an arrangement, the mean temperatures of the principal cities and towns of Great Britain as well as of foreign climates, might be attached, with many interesting points in animal and vegetable physiology. The extensive tables on temperature, collected and arranged by Sir James Clark, in his excellent treatise on Climate, would here serve as a useful guide.

It will be seen that the table now for the first time published, ranges from 15° to 374° Fahr., from -11° to $+190^{\circ}$ Centigrade, and from -9° to $+152^{\circ}$ Réaumur. It might have been extended, but this, it was considered, would have rendered it of very inconvenient size: and besides, the range here selected comprises all the most remarkable phenomena connected with heat. The more important facts relating to temperature above and below this range, will be found inserted in distinct paragraphs, on the table, with formula for the conversion of the degrees of Centigrade into those of Fahrenheit, and *vice versa*.

It will be only necessary to state generally those facts which the table is intended to illustrate. They will be found arranged opposite to their respective degrees, either on the Centigrade or Fahrenheit side, according to the space afforded. Some points have been necessarily omitted, in order not to render the table confused.

Thus it has been impossible to introduce all the maxima and minima of temperature in respect to climate, owing to the spaces being already occupied, but a selection has been made of some of the most important of these. The facts connected with temperature, placed on the scale, may be arranged under the heads of Climatology, Physical Geography, Chemistry and Physiology.

Climatology. 1. The mean temperatures of the principal countries, towns, and cities in the world, with the maxima and minima, as well as the mean summer and winter temperature of some of the most important localities.

2. The maximum degrees of heat, and the minimum degrees of cold, observed on the surface of the globe, including the accumulated temperatures of air, at Edinburgh and Geneva.

Physical Geography. 1. The temperature of the atmosphere, as observed on the summits of the principal mountains of the Old and New World, with the respective elevations attached — at the sea level in various latitudes, from the Arctic to the Antarctic seas, as well as in deep mines and other excavations in Europe and America.

2. The temperature of the ocean at the surface, and at various depths 12,420 feet, including the temperature of the Polar Seas, of the Mediterranean, Atlantic and Pacific, with the temperature of the Gulf stream.

3. The temperature of the waters of lakes and rivers at various depths, with the respective fathomings attached.

4. The temperature of the strata of the earth at various depths, observed in some of the deepest mines in the Old and New World.

5. The temperature of water raised in Artesian wells in Europe, from depths varying from 250 to 1794 feet.

6. The temperature of the principal thermal springs and baths observed in Europe, Africa, the West Indies and South America.

7. The temperature at which water boils at all the elevated and inhabited spots in the world, including the summits of the mountains of Switzerland, South America, and Central Asia; the boiling point for all elevations up to 5415 feet, and for 1054 feet depression below the level of the sea.

Chemistry. 1. The evaporating, boiling, fusing, melting, subliming and congealing points of all solids and liquids in chemistry, from 12° to 374° Fahr., from -11° to $+190^{\circ}$ Cent. and from -9 to $+152^{\circ}$ Réau., including the boiling points of the saturated solutions of numerous salts, and the melting points of a large number of alloys.

2. The temperature for fermentation of various kinds, malting, putrefaction, etherification, and other chemical processes.

3. The boiling points of alcohol and acids of various specific gravities, with the respective densities of the vapours.

4. The pressure or elastic force of the vapour of water, alcohol, oil of turpentine, and ether, at various temperatures.

5. The temperatures, with the corresponding pressures required for the liquefaction of the gases.

6. The temperature for the explosion and ignition of fulminating and combustible substances.

Physiology. 1. The maximum degrees of natural and artificial heat, and minimum degrees of cold, borne by man and animals.

2. The temperature of the body in man, mammalia, birds, reptiles, fishes, and insects.
3. The temperature at which hybernation takes place in certain animals.
4. The temperature for the germination of seeds, incubation, the artificial hatching of the ova of birds, fishes and insects.
5. The temperature for the growth of the sugar-cane, date, indigo, cotton tree, and for the cultivation of the vine.
6. The temperature for warm, tepid and vapour baths; the vapour baths of Russia and Finland.

As the value of a table of this kind, depends less on the compiler than on the observers on whom he relies, I feel bound to state that I am chiefly indebted to the following authorities:—for Climatology and Physical Geography: to Humboldt, Bonpland, Saussure, Boussingault, Rose, Ermann, Baer, Von Wrangell, Breislak, Phipps, Scoresby, Franklin, PARRY, Back, Ross, Pashtusoff, Zivolka, Cordier, Gay Lussac, Pouillet, Biot, Arago, Bertrand, Desfontaines, Gerard, Lhotsky, Schomburgk, Davidson, Forbes, Brewster, D'Abbadie, Moore and Beke;—for Chemistry and Physiology; to Berzelius, Dumas, Mitscherlich, Gaultier de Claubry, Peligot, Davy, Faraday, Ure, Brande, Graham, Turner, Dr. Davy and Liebig. In respect to the department of Physical Geography, I am much indebted to the foreign correspondence of the Athenæum.

Many of the facts I was enabled to collect or verify by personal observation during a journey through France, Italy, and Switzerland. Some of the chemical phenomena have also been derived from direct experiment. It is very probable that a few of the temperatures, in each department, will be found to differ from those given in some works on Chemistry; and, on this point, I have one remark to make, namely, that the greatest discrepancies will often be found among respectable authorities in regard to temperature. It is impossible here to enter into the causes of these discrepancies. I have invariably acted on the principle of selecting the best authorities; and where these differed, I have endeavoured to arrive at an approximation to the truth by experiment, or where this was impossible, by seeking for corroborative circumstances. A large number of observations, made by travellers, I have been obliged to reject, in some instances, owing to the omission or confusion of the + and — signs; and in others, owing to the observers having omitted to state what thermometers they employed. During the researches into which the compilation of this table has led me—occupying as it has done the occasional leisure of four years—my mind has been strongly impressed with the benefits which would accrue to science, if the philosophers of Europe would agree to employ only one scale, with small degrees, and so adjusted as to render entirely unnecessary the use of the + and — signs.

THERMOSTAT, is the name of an apparatus for regulating temperature, in vaporization, distillations, heating baths or hothouses, and ventilating apartments, &c.; for which I obtained a patent in the year 1831. It operates upon the physical principle, that when two thin metallic bars of different expansibilities are rivetted or soldered facewise together, any change of temperature in them will cause a sensible movement of flexure in the compound bar, to one side or other; which movement may be made to operate, by the intervention of levers, &c., in any desired degree, upon valves, stopcocks, stove-registers, air-ventilators, &c.; so as to regulate the temperature of the media in which the said compound bars are placed. Two long rulers, one of steel, and one of hard hammered brass, rivetted together, answer very well; the object being not simply to *indicate*, but to *control* or *modify* temperature. The following diagrams will illustrate a few out of the numerous applications of this instrument:—

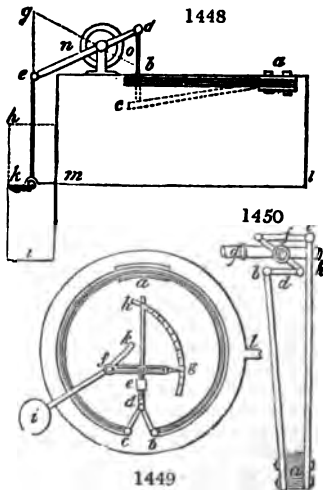


Fig. 1448. *a, b*, is a single thermostatic bar, consisting of two or more bars or rulers of differently expansible solids (of which, in certain cases, wood may be one): these bars or rulers are firmly rivetted or soldered together, face to face. One end of the compound bar is fixed by bolts at *a*, to the interior of the containing cistern, boiler, or apartment, *a l m b*, whereof the temperature has to be regulated,

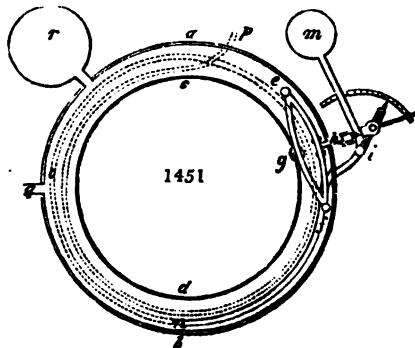
and the other end of the compound bar at *b*, is left free to move down towards *c*, by the flexure which will take place when its temperature is raised.

The end *b*, is connected by a link, *b d*, with a lever *d e*, which is moved by the flexure into the dotted position *b g*, causing the turning-valve, air-ventilator, or register, *o n*, to revolve with a corresponding angular motion, whereby the lever will raise the equiposed slide-damper *k i*, which is suspended by a link from the end *e*, of the lever *d*, into the position *k h*. Thus a hothouse or a water-bath may have its temperature regulated by the contemporaneous admission of warm, and discharge of cold air, or water.

Fig. 1449. *a b c* is a thermostatic hoop, immersed horizontally beneath the surface of the water-bath of a still. The hoop is fixed at *a*, and the two ends *b, c*, are connected by two links *b d, c d*, with a straight sliding rod *d h*, to which the hoop will give an endwise motion, when its temperature is altered; *e*, is an adjusting screw-nut on the rod *d h*, for setting the lever *f g*, which is fixed on the axis of the turning-valve or cock *f*, at any desired position, so that the valve may be opened or shut at any desired temperature, corresponding to the widening of the points *b, c*, and the consentaneous retraction of the point *d*, towards the circumference *a b c* of the hoop. *g h*, is an arc graduated by a thermometer, after the screw-piece *e* has been adjusted. Through a hole at *h*, the guide-rod passes; *i*, is the cold-water cistern; *i f h*, the pipe to admit cold water; *l*, the overflow pipe, at which the excess of hot water runs off.

Fig. 1450. shows a pair of thermostatic bars, bolted fast together at the ends *a*. The free ends *b, c*, are of unequal length, so as to act by the cross links *d, f*, on the stopcock *e*. The links are jointed to the handle of the turning plug of the cock, on opposite sides of its centre; whereby that plug will be turned round in proportion to the widening of the points *b, c*. *h g* is the pipe communicating with the stopcock.

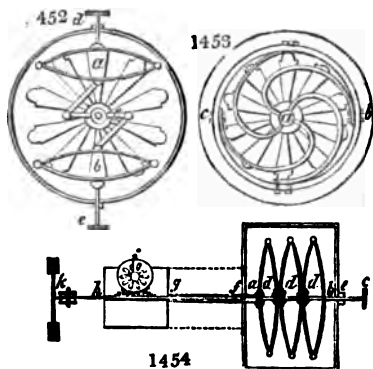
Suppose that for certain purposes in pharmacy, dyeing, or any other chemical art, a water-bath is required to be maintained steadily at a temperature of 150° F. : let the combined thermostatic bars, hinged together at *e, f*, *fig. 1451.*, be placed in the bath,



between the outer and inner vessels *a, b, c, d*, being bolted fast to the inner vessel at *g*; and have their sliding rod *h*, connected by a link with a lever fixed upon the turning plug of the stopcock *i*, which introduces cold water from a cistern *m*, through a pipe *m i n*, into the bottom part of the bath. The length of the link must be so adjusted that the flexure of the bars, when they are at a temperature of 150°, will open the said stopcock, and admit cold water to pass into the bottom of the bath through the pipe *i n*, whereby hot water will be displaced at the top of the bath through an open overflow-pipe at *g*. An oil bath may be regulated on the same plan; the hot oil overflowing from *g*,

into a refrigeratory worm, from which it may be restored to the cistern *m*. When a water bath is heated by the distribution of a tortuous steam pipe through it, as *i n o p*, it will be necessary to connect the link of the thermostatic bars with the lever of the turning plug of the steam-cock, or of the throttle valve *i*, in order that the bars, by their flexure, may shut or open the steam passage more or less, according as the temperature of the water in the bath shall tend more or less to deviate from the pitch to which the apparatus has been adjusted. The water of the condensed steam will pass off from the sloping winding-pipe *i n o p*, through the sloping orifice *p*. A saline, acid, or alkaline bath has a boiling temperature proportional to its degree of concentration, and may therefore have its heat regulated by immersing a thermostat in it, and connecting the working part of the instrument with a stopcock *i*, which will admit water to dilute the bath whenever by evaporation it has become concentrated, and has acquired a higher boiling point. The space for the bath, between the outer and inner pans, should communicate by one pipe with the water-cistern *m*; and by another pipe with a safety cistern *r*, into which the bath may be allowed to overflow during any sudden excess of ebullition.

Fig. 1454. is a thermostatic apparatus, composed of three pairs of bars *d, d, d*, which are represented in a state of flexure by heat; but they become nearly straight and parallel when cold. *a b c* is a guide rod, fixed at one end by an adjusting screw *e*, in the strong frame *f e*, having deep guide grooves at the sides. *f g*, is the working-rod, which moves endways when the bars *d, d, d*, operate by heat or cold. A square register-plate *h g*, may be affixed to the rod *f g*, so as to be moved backwards and for-



supposed to be on the outside. The plane of the damper-plate will, in this case, be turned more directly into the passage of the draught through the chimney by increase of temperature.

Fig. 1453. represents a circular turning register, such as is used for a stove, or stove-grate, or for ventilating apartments; it is furnished with a series of spiral thermostatic bars, each bar being fixed fast at the circumference of the circle *b, c*, of the fixed plate of the air-register; and all the bars act in concert at the centre *a* of the turning part of the register, by their ends being inserted between the teeth of a small pinion, or by being jointed to the central part of the turning plate by small pins.

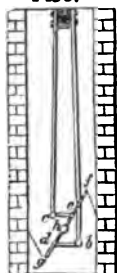


Fig. 1452. represents another arrangement of my thermostatic apparatus applied to a circular turning register, like the preceding, for ventilating apartments. Two pairs of compound bars are applied so as to act in concert, by means of the links *a, b, c*, on the opposite ends of a short lever, which is fixed on the central part of the turning plate of the air-register. The two pairs of compound bars *a, b*, are fastened to the circumference of the fixed plate of the turning register, by two sliding rods *a, d, b, c*, which are furnished with adjusting screws. Their motion or flexure is transmitted by the links *a, c* and *b, c*, to the turning plate, about its centre, for the purpose of shutting or opening the ventilating sectorial apertures, more or less, according to the temperature of the air which surrounds the thermostatic turning register. By adjusting the screws *a, d*, and *b, c*, the turning register is made to close all its apertures at any desired degree of temperature; but whenever the air is above that temperature, the flexure of the compound bars will open the apertures.

THIMBLE (*Dé à coudre*, Fr.; *Fingerhut* (*fingerhat*), Germ.); is a small truncated metallic cone, deviating little from a cylinder, smooth within, symmetrically pitted on the outside with numerous rows of indentations, which is put upon the tip of the middle finger of the right hand, to enable it to push the needle readily and safely through cloth or leather, in the act of sewing. This little instrument is fashioned in two ways; either with a pitted round end, or without one; the latter, called the open thimble, being employed by tailors, upholsterers, and, generally speaking, by *needle-men*. The following ingenious process for making this essential implement, the contrivance of M. M. Rouy and Berthier, of Paris, has been much celebrated, and very successful. Sheet-iron, one twenty-fourth of an inch thick, is cut into strips, of dimensions suited to the intended size of the thimbles. These strips are passed under a punch-press, whereby they are cut into discs of about 2 inches diameter, tagged together by a tail. Each strip contains one dozen of these blanks. A child is employed to make them red-hot, and to lay them on a mandril nicely fitted to their size. The workman now strikes the middle of each with a round-faced punch, about the thickness of his finger, and thus sinks it into the concavity of the first mandril. He then transfers it successively to another mandril, which has five hollows of successively increasing depth; and, by striking it into them, brings it to the proper shape.

A second workman takes this rude thimble, sticks it in the chuck of his lathe, in order to polish it within, then turns it outside, marks the circles for the gold ornament, and indents the pits most cleverly with a kind of milling tool. The thimbles are next annealed, brightened, and gilt inside, with a very thin cone of gold leaf, which is firmly united to the surface of the iron, simply by the strong pressure of a smooth steel man-

wards thereby, according to the variations of temperature; or the rod *f, g*, may cause the circular turning air-register, *i*, to revolve by rack and wheel-work, or by a chain and pulley. The register-plate *h, g*, or turning register *i*, is situated at the ceiling or upper part of the chamber, and serves to let out hot air. *k*, is a pulley, over which a cord runs to raise or lower a hot-air register *l*, which may be situated near the floor of the apartment or hot-house, to admit hot air into the room. *c*, is a milled head, for adjusting the thermostat, by means of the screw at *e*, in order that it may regulate the temperature to any degree.

Fig. 1455. represents a chimney, furnished with a *pyrostat* *a, b, c*, acting by the links *b, d, e, c*, on a damper *f, h, g*. The more expansible metal is in the present example

drill. A gold fillet is applied to the outside, in an annular space turned to receive it, being fixed, by pressure at the edges, into a minute groove formed on the lathe.

Thimbles are made in this country by means of moulds in the stamping-machine. See STAMPING OF METALS.

THORINA, is a primitive earth, with a metallic basis, discovered in 1828, by Berzelius. It was extracted from the mineral *thorite*, of which it constitutes 58 per cent., and where it is associated with the oxide of iron, lead, manganese, tin, and uranium, besides earths and alkalis, in all 12 substances. Pure thorina is a white powder, without taste, smell, or alkaline reaction on litmus. When dried and calcined, it is not affected by either the nitric or muriatic acid. It may be fused with borax into a transparent glass, but not with potash or soda. Fresh precipitated thorina is a hydrate, which dissolves readily in the above acids, as well as in solutions of the carbonates of potash, soda, and ammonia, but not in these alkalis in a pure state. This earth consists of 74.5 parts of the metal *thorium*, combined with 100 of oxygen. Its hydrate contains one equivalent prime of water. It is hitherto merely a chemical curiosity, remarkable chiefly for a density of 9.402, far greater than that of all the earths, and even of copper.

THREAD MANUFACTURE. The doubling and twisting of cotton or linen yarn into a compact thread, for weaving bobbin-net, or for sewing garments, is performed by a machine resembling the throstle of the cotton-spinner. Fig. 1456. shows the thread-frame in a transverse section, perpendicular to its length. *a*, is the strong framing of cast iron; *b*, is the *creel*, or shelf, in which the bobbins of yarn *l*, *l*, are set loosely upon their respective skewers, along the whole line of the machine, their lower ends turning in oiled steps, and their upper in wire eyes; *c*, is a glass rod, across which the yarn runs as it is unwound; *d*, *d*, are oblong narrow troughs, lined with lead, and filled with water, for moistening the thread during its torsion; the threads being made to pass through eyes at the bottom of the fork *e*, which has an upright stem for lifting it out, without wetting the fingers, when anything goes amiss; *f*, *f*, are the pressing rollers, the under one *g*, being of smooth iron, and the upper one *h*, of box-wood; the former extends from end to end of the frame, in lengths comprehending 18 threads, which are joined by square pieces, as in the drawing-rollers of the mule-jenny. The necks of the under rollers are supported, at the ends and the middle, by the standards *i*, secured to square bases *j*, both made of cast iron. The upper cylinder has an iron axis, and is formed of as many rollers as there are threads; each roller being kept in its place upon the lower one by the guides *k*, whose vertical slots receive the ends of the axes.

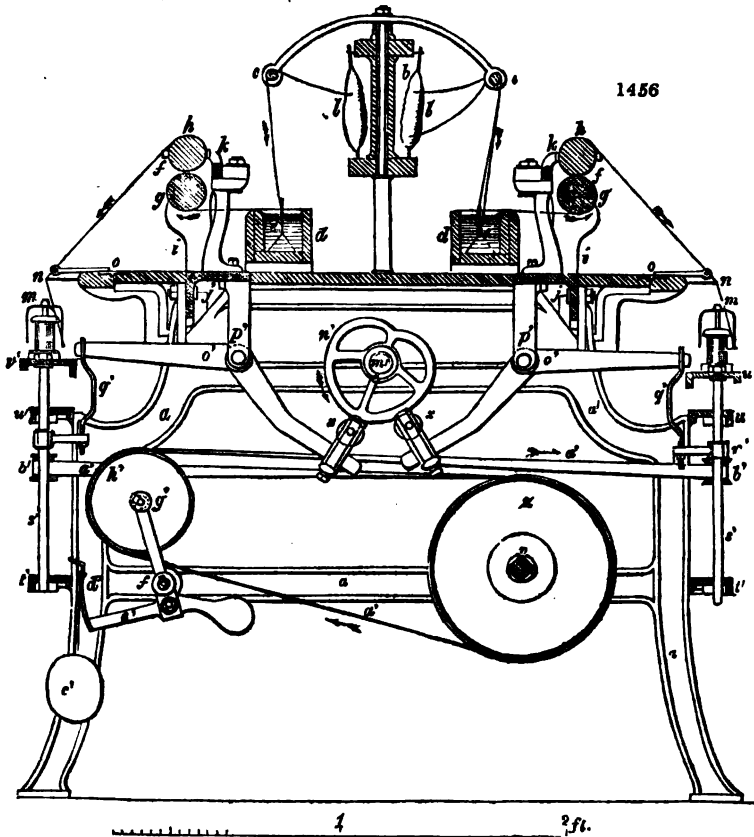
The yarn delivered by the bobbin *l*, glides over the rod *c*, and descends into the trough *d*, where it gets wetted: on emerging, it goes along the bottom of the roller *g*, turns up, so as to pass between it and *h*, then turns round the top of *h*, and finally proceeds obliquely downwards, to be wound upon the bobbin *m*, after traversing the guide-eye *n*. These guides are fixed to the end of a plate which may be turned up by a hinge-joint at *o*, to make room for the bobbins to be changed.

There are three distinct simultaneous movements to be considered in this machine: 1. that of the rollers, or rather of the under roller, for the upper one revolves merely by friction; 2. that of the spindles *m*, *m'*; 3. the up-and-down motion of the bobbins upon the spindles.

The first of these motions is produced by means of toothed wheels, upon the right hand of the under set of rollers. The second motion, that of the spindles, is effected by the drum *z*, which extends the whole length of the frame, turning upon the shaft *v*, and communicating its rotary movement (derived from the steam pulley) to the whorl *h'* of the spindles, by means of the endless band or cord *a'*. Each of these cords turns four spindles, two upon each side of the frame. They are kept in a proper state of tension by the weights *e'*, which act tangentially upon the circular arc *d'*, fixed to the extremity of the bell-crank lever *e' f' g'*, and draw in a horizontal direction the tension pulleys *h*, embraced by the cords. The third movement, or the vertical traverse of the bobbins, along the spindles *m*, takes place as follows:—

The end of one of the under rollers carries a pinion, which takes into a carrier wheel that communicates motion to a pinion upon the extremity of the shaft *m'*, of the heart-shaped pulley *w'*. As this eccentric revolves, it gives a reciprocating motion to the levers *e'*, *e'*, which oscillate in a vertical plane round the points *p'*, *p'*. The extremities of these levers on either side act by means of the links *q'*, upon the arms of the sliding sockets *r'*, and cause the vertical rod *s'*, to slide up and down in guide-holes at *t'*, *w'*, along with the cast-iron step *o'*, which bears the bottom washer of the bobbins. The periphery of the heart-wheel *w'*, is seen to bear upon friction wheels *x*, *x'*, set in frames adjusted by screws upon the lower end of the bent levers, at such a distance from the point *p'*, as that the traverse of the bobbins may be equal to the length of their barrel.

By adapting change pinions and their corresponding wheels to the rollers, the delivery of the yarn may be increased or diminished in any degree, so as to vary the degree of



twist put into it by the uniform rotation of the drum and spindles. The heart motion being derived from that of the rollers, will necessarily vary with it.

Silk thread is commonly twisted in lengths of from 50 to 100 feet, with hand reels somewhat similar to those employed for making ropes by hand.

THUNDER CONDUCTORS. The several nautical and scientific conditions which the system of lightning conductors in ships professes to satisfy, are as follows:—

The conductors are spacious and always in place, consequently ready to meet the most unexpected danger at all times and under any circumstances in which the general fabric in all its casualties may become placed. This system of conductors, whilst being permanently fixed throughout their whole extent, still admit, upon demonstrable principles of electrical action, the perfect motion of the sliding masts one upon the other, or of any part of the mast being removed, either by accident or design, without for an instant interfering with the protecting power. The conductors are independent of the officers or crew of the ship; so that the sailors are never required to handle or replace them, often a very perilous and annoying service. The conducting plates are quite clear of the standing and running rigging; the whole series is calculated to resist external violence, and at the same time yield to any flexure or strain incidental to the spars to which they are applied. Finally, the whole system is so arranged that a discharge of lightning falling on any part of the ship could scarcely enter upon any circuit in its course to the sea of which the conductors did not form a part; hence has arisen that perfect security which experience has shown to be derived from such a system.

In the original conception of this system Sir Snow Harris was led to consider the electrical discharge, as seen in the phenomenon of lightning, to be an explosive form of the action of some unknown agency in nature when forcing its way through resisting matter such as air, all vitreous and resinous bodies, and some other kinds of matter: whilst in traversing other bodies offering but a very small resistance to its progress, this explosive

form of action we call lightning becomes transformed into a sort of comparatively quiescent current. The attempt was therefore to bring a ship as far as possible into that passive or non-resisting state which she could possess as regards the electrical discharge, supposing the entire mass were metallic throughout; so that from the instant the agency of lightning struck upon any portion of the masts aloft, the explosive action would vanish, and the electrical discharge be prevented from traversing the vessel under the form of lightning. The following extract from the official journal of H. M. S. Conway, 23, whilst proving with a great natural experiment in common with numerous other cases the truth of this deduction, is of no ordinary interest in practical science:—

“Port Louis, Isle of France, 9th March, 1846, 11 45 A. M. The pendant staff at main-top-mast-head was shivered in pieces by lightning, Harris's conductor carrying off the fluid without further damage.”

The ship was refitting at this time, and the top-gallant masts on deck, so that a small spar was set up at the top-mast-head as a temporary support for the pendant; this spar had not consequently any conductor on it. It is seen by the ship's journal that the spar was shivered in pieces by the explosive action, which became immediately transformed into a comparatively quiescent current on reaching the line of conduction.

The report of the thunder was as if one of the main-deck guns had been fired. The gunner, who was sitting in his berth immediately under one of the lateral branches of the conductor passing through the ship, saw, through the scuttle port, a brilliant blaze of light from the ship upon the sea, but experienced no inconvenience.

TILES. See BRICKS.

TILTING OF STEEL. See STEEL. *Rees's Cyclopadia* contains an excellent article on this subject.

TIN (*Etain*, Fr.; *Zinn*, Germ.); in its pure state, has nearly the colour and lustre of silver. In hardness it is intermediate between gold and lead; it is very malleable, and may be laminated into foil less than the thousandth of an inch in thickness; it has an unpleasant taste, and exhales on friction a peculiar odour; it is flexible in rods or straps of considerable strength, and emits in the act of bending a crackling sound, as if sandy particles were intermixed, called the creaking of tin. A small quantity of lead, or other metal, deprives it of this characteristic quality. Tin melts at 442° Fahr., and is very fixed in the fire at higher heats. Its specific gravity is 7.29. When heated to redness with free access of air, it absorbs oxygen with rapidity, and changes first into a pulverulent gray protoxide, and by longer ignition into a yellow-white powder, called *putty* of tin. This is the peroxide, consisting of 100 of metal + 27.2 of oxygen.

Tin has been known from the most remote antiquity; being mentioned in the books of Moses. The Phœnicians carried on a lucrative trade in it with Spain and Cornwall. There are only two ores of tin; the peroxide, or tin-stone, and tin pyrites; the former of which alone has been found in sufficient abundance for metallurgic purposes. The external aspect of tin-stone has nothing very remarkable. It occurs sometimes in twin crystals; its lustre is adamantine; its colours are very various, as white, gray, yellow, red, brown, black; specific gravity 6.9 at least; which is, perhaps, its most striking feature. It does not melt by itself before the blowpipe; but is reducible in the smoky flame or on charcoal. It is insoluble in acids. It has somewhat of a greasy aspect; and strikes fire with steel.

Tin-stone occurs disseminated in the ancient rocks, particularly granite; also in beds and veins, in large irregular masses, called *stockwerks*; and in pebbles, an assemblage of which is called stream-works, where it occasionally takes a ligneous aspect, and is termed *wood-tin*.

This ore has been found in few countries in a workable quantity. Its principal localities are, Cornwall, Bohemia, Saxony, in Europe; and Malacca and Banca, in Asia. The tin-mines of the Malay peninsula lie between the 10th and 6th degree of south latitude; and are most productive in the island of Junck-Ceylon, where they yield sometimes 800 tons per annum, which are sold at the rate of 48*l.* to 60*l.* each. The ores are found in large caves near the surface; and though actively mined for many centuries, still there is easy access to the unexhausted parts. The mines in the island of Banca, to the east of Sumatra, discovered in 1710, are said to have furnished, in some years, nearly 3500 tons of tin. Small quantities occur in Gallicia in Spain, the department of Haute Vienne in France, and in the mountain chains of the Fichtel and Riesengebürge in Germany. The columnar pieces of pyramidal tin-ore from Mexico and Chile are products of stream-works. Small groups of black twin crystals have been lately discovered in the albite rock of Chesterfield in Massachusetts.

The Cornish ores occur—1. in small strata or veins, or in masses; 2. in stockwerks or congeries of small veins; 3. in large veins; 4. disseminated in alluvial deposits.

The stanniferous small veins, or thin flat masses, though of small extent, are sometimes very numerous, interposed between certain rocks, parallel to their beds, and are commonly called tin-floors. The same name is occasionally given to stockwerks. In

the mine of Botalack, a *tin-floor* has been found in the killas (primitive schistose rock), thirty-six fathoms below the level of the sea; it is about a foot and a half thick, and occupies the space between a principal vein and its ramification; but there seems to be no connexion between the *floor* and the great vein.

2. Stockwerks occur in granite and in the felspar porphyry, called in Cornwall, *elvan*. The most remarkable of these in the granite, is at the tin-mine of Carclase, near *St. Austle*. The works are carried on in the open air, in a friable granite, containing felspar disintegrated into *kaolin*, or china clay, which is traversed by a great many small veins, composed of tourmaline, quartz, and a little tin-stone, that form black delineations on the face of the light-gray granite. The thickness of these little veins rarely exceeds 6 inches, including the adhering solidified granite, and is occasionally much less. Some of them run nearly east and west, with an almost vertical dip; others, with the same direction, incline to the south at an angle with the horizon of 70 degrees.

Stanniferous stockwerks are much more frequent in the elvan (porphyry); of which the mine of Trewidden-ball is a remarkable example. It is worked among flattened masses of *elvan*, separated by strata of *killas*, which dip to the east-north-east at a considerable angle. The tin ore occurs in small veins, varying in thickness from half an inch to 8 or 9 inches, which are irregular, and so much interrupted, that it is difficult to determine either their direction or their inclination.

3. The large and proper metalliferous veins are not equally distributed over the surface of Cornwall and the adjoining part of Devonshire; but are grouped into three districts; namely, 1. In the south-west of Cornwall, beyond Truro; 2. In the neighbourhood of *St. Austle*; and 3. In the neighbourhood of Tavistock in Devonshire.

The first group is by far the richest, and the best explored. The formation most abundant in tin mines is principally granitic; whilst that of the copper mines is most frequently schistose or killas; though with numerous exceptions. The great tin veins are the most ancient metalliferous veins in Cornwall; yet they are not all of one formation, but belong to two different systems. Their direction is, however, nearly the same, but some of them dip towards the north, and others towards the south. The first are older than the second; for in all the mines where these two sets of veins are associated, the one which dips to the north, cuts across and throws out the one which dips to the south. See *Mines*, p. 171.

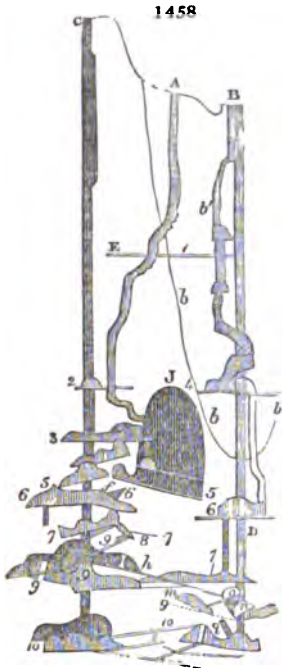
At Trevenance mines, the two systems of tin veins are both intersected by the oldest of the copper veins; indicating the prior existence of the tin veins. In *fig. 1457*,

b, marks the first system of tin veins; *c*, the second; and *d*, the east and west copper veins. Some of these tin veins, as at Poldice, have been traced over an extent of two miles; and they vary in thickness from a small fraction of an inch to several feet, the average width being from 2 to 4 feet; though this does not continue uniform for any length, as these veins are subject to continual narrowings and expansions. The gangue is quartz, chlorite, tourmaline, and sometimes decomposed granite and fluor spar.

4. *Alluvial tin ore, stream tin*. — Peroxide of tin occurs disseminated both in the alluvium which covers the gentle slopes of the hills adjoining the rich tin-mines, and also in the alluvium which fills the valleys that wind round their base; but in these numerous deposits the tin-stone is rarely distributed in sufficient quantities to make it worth the working. The most important explorations of *alluvial tin ore* are grouped in the environs of *St. Just* and *St. Austle*; where they are called *stream-works*; because water is the principal agent employed to separate the metallic oxide from the sand and gravel.

The tin mine of Altenberg, in Saxony (*fig. 1458*, which is a vertical projection in a plane passing from west to east,) is remarkable for a stockwerke, or interlaced mass of ramifying veins, which has been worked ever since the year 1458. The including rock is a primitive porphyry, superposed upon gneiss; becoming very quartzose as it approaches the lode. This is usually disseminated in minute particles, and accompanied with wolfram, copper and arsenical pyrites, *fer oligiste*, sulphuret of molybdenum, and bismuth, having gangues of lithomarge, fluor spar, mica, and felspar. The space which the ore occupies in the heart of the quartz, is a kind of *dædalus*, the former being often so dispersed among the latter as to seem to merge into it; whence it is called by the workmen *zwitter*, or *ambiguous*. In 1620, the mine was worked by 21 independent companies, in a most irregular manner, whereby it was damaged to a depth of 170 fathoms by a dreadful downfall of the roofs. This happened on a Sunday, providentially, when the pious miners were all at church. The depth of this abyss, marked by the curved line

Δ , δ , b , is 66 fathoms; but the devastation is manifest to a depth of 95 fathoms below that curve, and 35 fathoms below the actual workings, represented at the bottom of the shaft under n . The parts excavated are shaded black in the figure.



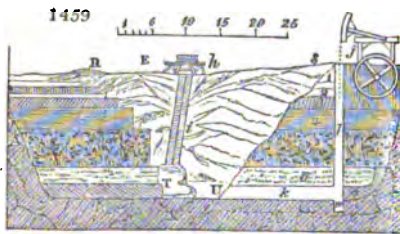
There are two masses of ore, one under the shaft a , and another under the shaft c ; which at the levels 5 and 10 are in communication, but not at 6, 7. There is a direct descent from 8 to 9. The deposits are by no means in one vertical plane, but at a considerable horizontal distance from each other. A is the descending shaft; n is the extraction shaft, near the mouth of which there is a water-wheel; c is another extraction shaft, worked also by means of a water-wheel. A and c are furnished with ladders, but for a the ladders are placed in an accessory shaft δ ; under n , a shaft is sunk for pumping out the water, by means of an hydraulic wheel at n ; x is the gallery or drift for admitting the water which drives the wheels. This falls 300 feet, and ought to be applied to a water-pressure engine, instead of the paddles of a wheel. At n , is the gallery of discharge for the waters, which serves also to ventilate the mine, being cut to the day, through 936 toises of syenitic porphyry and gneiss. j , is a great vaulted excavation. The mine has 13 stages of galleries, of which 11 serve for extracting the ore; 1 is the mill-course; the rest are marked with the numbers 2, 3, 4, &c.; each having besides a characteristic German name. The rare mineral called *topaz pycnite* is found in this mine, above 10, between the shafts c and n .

The only rule observed in taking ore from this mine, has been to work as much out of each of these levels as is possible, without endangering the superincumbent or collateral galleries; on which account many pillars are constructed to support the roofs. The mine yields annually 1600 quintals (Leipzig); of tin, being four-fifths of the whole furnished by the

district of Altenberg; to produce which, 400,000 quintals of ore are raised. 1000 parts of the rock yield 8 of concentrated schlich, equivalent to only 4 of metal; being only 1 in 250 parts.

But the most extensive and productive stream-works, are those of Pentowan, near St. Austle.

Fig. 1459. represents a vertical section of the Pentowan mine, taken from the stream-work, *Happy Union*. A vast excavation, n, t, u, s , has been hollowed out in the open air, in quest of the alluvial tin ore τ , which occurs here at an unusual depth, below the level of the strata x, s .



Before getting at this deposit, several successive layers had to be sunk through; namely, 1, 2, 3; the gravel, containing in its middle a band of ochreous earth 2, or ferruginous clay; 4, a black peat, perfectly combustible, of a coarse texture, composed of reeds and woody fibres, cemented into a mass by a fine loam; 5, coarse sea-sand, mingled with

marine shells; 6, a blackish marine mud, filled with shells. Below these the deposit of tin-stone occurs, including fragments of various size, of clay slate, flinty slate, quartz, iron ore, jasper; in a word, of all the rocks and gangues to be met with in the surrounding territory, with the exception of granite. Among these fragments there occur, in rounded particles, a coarse quartzose sand, and the tin-stone, commonly in small grains and crystals. Beneath the bed τ , the clay slate occurs, called *killas* (Δ, x, τ), which supports all the deposits of more recent formation.

The system of mining is very simple. The successive beds, whose thickness is shown in the figure, are visibly cut out into steps or platforms. By a level or gallery of efflux k , the waters flow into the bottom of the well l, m , which contains the drainage pumps; and these are put in action by a machine j , moved by a water-wheel. The extraction of the ore is effected by an inclined plane i , cut out of one of the sides of the excavation,

at an angle of about 45 degrees. At the lower end of this sloping pathway there is a place of loading; and at its upper end *a*, a horse-gin, for alternately raising and lowering the two baskets of extraction on the pathway *i*.

Mise tin requires peculiar care in its mechanical preparation or dressing, on account of the presence of foreign metals, from which, as we have stated, the stream tin is free.

1. As the mine tin is for the most part extremely dispersed through the gangue, it must be all stamped and reduced to a very fine powder, to allow the metallic particles to be separated from the stony matters.

2. As the density of tin-stone is much greater than that of most other metallic ores, it is less apt to run off in the washing; and may, therefore, be dressed so as to be completely stripped of every matter not chemically combined.

3. As the peroxide of tin is not affected by a moderate heat, it may be exposed to calcination; whereby the specific gravity of the associated sulphurets and arseniurets is so diminished as to facilitate their separation.

We may therefore conclude, that tin ore should be first of all pounded very fine in the stamp-mill, then subjected to reiterated washings, and afterwards calcined. The order of proceeding in Cornwall is as follows:—

1. *Cleaning the ore.*—This is usually done at the mouth of the gallery of efflux, by agitating the ore in the stream of water as it runs out. Sometimes the ore is laid on a grating, under a fall of water.

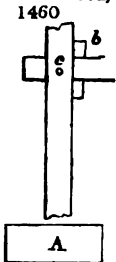
2. *Sorting.*—The ore thus cleaned, is sorted on the grate, into four heaps: 1. stones rich in tin; 2. stones containing both tin and copper ore; 3. copper ore; 4. sterile pieces, composed in a great measure of stony gangue, with iron and arsenical pyrites. In those veins where there is no copper ore, the second and third heaps are obviously absent. When present, the compound ore is broken into smaller pieces with a mallet, and the fragments are sorted anew.

3. *Stamping.*—The stanniferous fragments (No. 1.) are stamped into a sand, of greater or less fineness, according to the dissemination of the tin-stone in the gangue. The determination of the size of the sand, is an object of great importance. It is regulated by a copper plate pierced with small holes, through which every thing from the stamping-mill must run off with the rapid stream introduced for this purpose. This plate forms the front of the stamp cistern.

Several years ago, all the stamp mills were driven by water-wheels, which limited the quantity of ore that could be worked to the hydraulic power of the stream or waterfall; but since the steam engine has been applied to this purpose, the annual product of tin has been greatly increased. On the mine of Huel Vor, there are three steam engines appropriated to the stamping-mills. Their force is 25 horses at least. One of these machines, called *south stamps*, drives 48 pestles; a second, called *old stamps*, drives 36; and a third, 24. The weight of these pestles varies from 370 to 387 pounds; and they generally rise through a space of 10½ inches. The machine called *south stamps*, the strongest of the three, gives 17½ blows in the minute, each pestle being lifted twice for every stroke of the piston. The steam engine of this mill has a power of 25 horses, and it consumes 1062 bushels of coals in the month. Three pestles constitute a battery, or stamp-box.

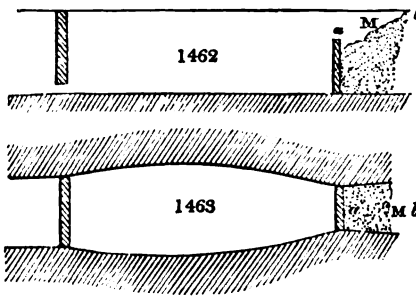
Washing and stamping of tin ores at Polgooth, near St. Austle.—The stamps or pestles are of wood, 6 inches by 5½ in the square: they carry lifting bars *b*, secured with a wooden wedge and a bolt of iron, and they terminate below in a lump of cast iron *a*, called the head, which is fastened to them by a tail, and weighs about 2½ cwt. The shank of the pestle is strengthened with iron hoops. A turning-shaft communicates motion to the stamps by cams stuck round its circumference, so arranged that the second falls while the first and third of each set are uplifted. There are 4 cams on one periphery, and the shaft makes 7 turns in the minute. Each stamp, therefore, gives 28 strokes per minute, and falls through a space of 7½ inches. The stamp chest is open behind, so that the ore slips away under the pestles, by its weight, along the inclined plane with the stream of water. The bottom of the troughs consists of stamped ore. With 6 batteries of 6 pestles each, at Poldice, near Redruth, 120 bags of ore are stamped in 12 hours; each bag containing 18 gallons of 282 cubic inches; measuring altogether 352 cubic feet, and 864 cubic inches.

The openings in the front sides of the troughs are nearly 8 inches by 7½: they are fitted with an iron frame, which is closed with sheet iron, pierced with about 160 holes in the square inch, bored conically, being narrower within. The ore, on issuing, deposits its *rough* in the first basin, and its *slimes* in the following basins. The rough is washed in *buddles* (see LEAD, page 421), and in *tossing tubs*; the *slimes* in *trunks*, and upon a kind of twin tables, called *rucks*. Into the *tossing-tub*, or *dolly*, fig. 1461., the stamped ore is thrown, along with a certain quantity of water, and a workman stirs it about

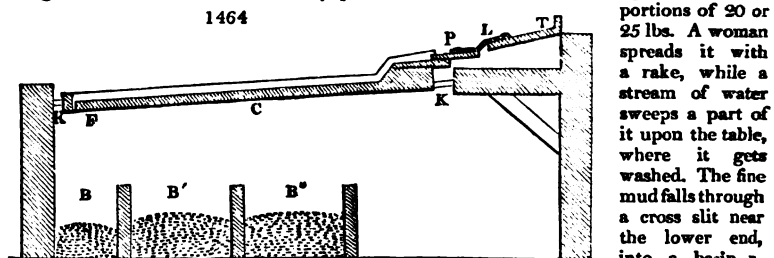


with an iron shovel for three or four minutes. He then removes a little of the water with a handled pitcher, and strikes the sides of the tub for 8 or 10 minutes with a hammer, which hastens the subsidence of the denser parts. The water is next poured off by inclining the tub to one side. In one operation of this kind, four distinct strata of the ores may be procured, as indicated by the lines *a b, c d, e f g, h i k*, in the figure. The portion *n* is to be washed again in the trunking-box, *figs. 1462, 1463*; *n* is to be washed upon the German chests or racks, *fig. 1464*; *c*, the most considerable, is put aside, as schlich fit for the market; *n*, forming a nucleus in the centre of the tub, is to be passed through sieves of copper wire, having 18 meshes in the square inch. This product thus affords a portion *n'*, which passes through the sieve, and *n''* which remains upon it; the latter is sometimes thrown away, and at others is subjected to the operation called the *tie*, *viz.*, a washing upon the sloping bottom of a long trough.

The slimes are freed from the lighter mud in the trunking-box, *figs. 1462, 1463*; which is from 7 to 8 feet long. Being accumulated at *x*, the workman pushes them back with a shovel from *a* towards *b*.



The metallic portion is carried off, and deposited by the stream of water upon the table; but the earthy matters are floated along into a basin beyond it. The product collected in the chest is divided into two portions; the one of which is washed once, and the other twice, upon the rack, *fig. 1464*. This is composed of a frame *c*, which carries a sloping board or table, susceptible of turning round to the right or left upon two pivots, *x, k*. The head of the table is the inclined plane *r*. A small board *t*, which is attached by a band



of leather *l*, forms the communication with the lower table *c*, whose slope is generally 5 inches in its whole length of 9 feet; but this may vary with the nature of the ore, being somewhat less when it is finely pulverized. The ore is thrown upon *r*, in small portions of 20 or 25 lbs. A woman spreads it with a rake, while a stream of water sweeps a part of it upon the table, where it gets washed. The fine mud falls through a cross slit near the lower end, into a basin *a*.

After working for a few minutes, should the schlich seem tolerably rich, the operative turns the table round its axis *x, k*, so as to tumble it into the boxes below. The mud is in *B*; an impure schlich in *B'*, which must be washed again upon the rack; and a schlich fit for roasting in *B''*.

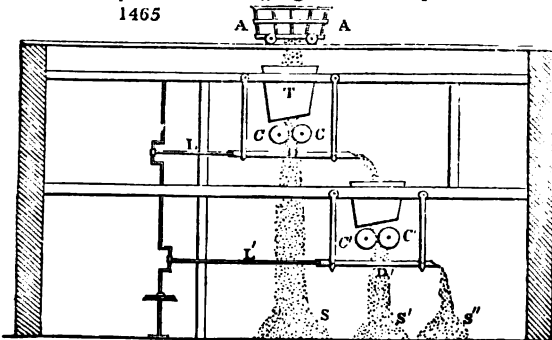
The slope of the rack-table for washing the roasted tin ore, is 7½ inches in the 9 feet.

Crushing rolls at the Pembroke mines. — Waggon, moved on a railway by an endless rope, bring the ore to be crushed, immediately over the rolls, as shown in *fig. 1465*. A trap being opened in the side of the waggon, the ore falls into the hopper *r*, whence it passes directly between the twin cylinders *c, c*, and next upon the sieve *d*, which receives a seesaw motion horizontally, by means of the rod *l*, and the crank of the upright turning-shaft. The finer portion of ore, which passes through that sieve, forms the heap *s*. The coarser portion is tossed over the edge of the sieve, and falls between the cylinders *c' c'*, upon a lower level, and forms the second heap *s'* of sifted, and *s''* of unsifted, ore.

The holes of the sieves *d, d'*, being of the same size, the products *s, s'*, are of the same fineness. *s'* is ground again, being mixed, in the uppermost hopper *r*, along with the lumps from the waggon.

The diameter and length of the under rolls (see *fig. 1466.*) are each 16 inches. *a*, *b*, is the square end of the gudgeon *t*, which prevents the shaft shifting laterally out

1465



of its place. The diameter of the upper rolls is 18 inches, but their length is the same. Both are made of white cast iron, *chilled* or case-hardened by being cast in iron moulds instead of sand; and they last a month, at least, when of good quality. They make from 10 to 15 turns in a minute, according to the hardness of the ores of tin or copper; and can

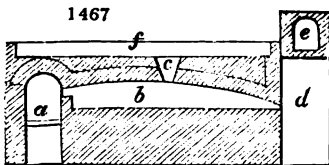
grind about 50 tons of rich copper ore in 12 hours; but less of the poorer sort.

The next process is the calcination in the *burning-house*; which includes several reverberatory furnaces. At the mine of Poldice, they are 4 or 5 yards long, by from 2½ to 3 yards wide. Their hearth is horizontal; the elevation, about 26 inches high near the fireplace, which is in the front; it is closed by a plate-iron door, turning

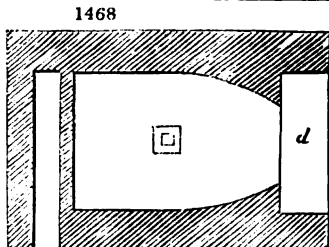
on hinges. Above the door there is a chimney, to let the sulphureous and arsenical vapours fly off, which escape out of the hearth, without annoying the workmen. This chimney leads to horizontal flues, in which the arsenious acid is condensed.

Six hundred weight of ore are introduced; the calcination of which takes from 12 to 18 hours, according to the quantity of pyrites contained in the ore. At the beginning of the operation, a moderate heat is applied; after which it is pushed to a dull red, and kept so during several hours. The door is shut; the materials are stirred from time to time with an iron rake, to expose new surfaces, and prevent them from agglutinating or *herning*, as the workmen say. The more pyrites is present, the more turning is necessary. Should the ore contain black oxide of iron, it becomes peroxidised, and is then easily removed by a subsequent washing.

Figs. 1467, 1468. represent the furnace employed at Altenberg, in Saxony, for roasting tin ores. *a* is the grate; *b*, the sole of the roasting hearth; *c*, an opening in the arched



roof for introducing the dried schlich (the ground and elutriated ore); *d*, is the smoke-mantle or chimney-hood, at the end of the furnace, under which the workmen turn over the spread schlich, with long iron rods bent at their ends; *e*, is the poison vent, which conducts the arsenical vapours to the poison chamber (*giftkammer*) of condensation.



When the ore is sufficiently calcined, as is shown by its ceasing to exhale vapours, it is taken out, and exposed for some days to the action of the air, which decomposes the sulphurets, or changes them into sulphates. The ore is next put into a tub filled with water, stirred up with a wooden rake, and left to settle; by which means the sulphate of copper that may have been formed, is dissolved out. After some time, this water is drawn off into a large tank, and its copper recovered by precipitation with pieces of old iron. In this way, almost all the copper contained in the tin ore is extracted.

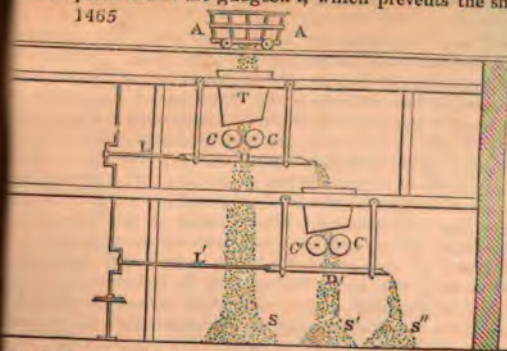
The calcined ore is sifted, and treated again on the racks, as above described. The pure schlich, called *black tin*, is sold under this name to the smelters; and that which collects on the middle part of the inclined wash-tables, being much mixed with wolfram, is called *mock lead*. This is passed once more through the stamps, and washed; when it also is sold as *black tin*.

Stream tin is dressed by similar methods: 1. by washing in a trunking-box, of such dimensions that the workman stands upon it in thick boots, and makes a skilful use



diameter and length of the under rolls (see fig. 1466.) are each 16 inches. the square end of the gudgeon *t*, which prevents the shaft shifting laterally out

1465



of its place. The diameter of the upper rolls is 18 inches, but their length is the same. Both are made of white cast iron, chilled or case-hardened by being cast in iron moulds instead of sand; and they last a month, at least, when of good quality. They make from 10 to 15 turns in a minute, according to the hardness of the ores of tin or copper; and can

about 50 tons of rich copper ore in 12 hours; but less of the poorer sort.

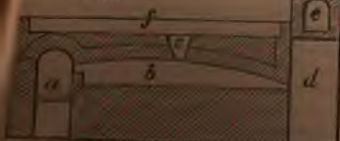
The next process is the calcination in the burning-house; which includes several reverberatory furnaces. At the mine of Poldice, they are 4 or 5 yards long, by from 2½ to 3 yards wide. Their hearth is horizontal; the elevation, about 26 inches high near the fireplace, sinks slightly towards the chimney. There is but one opening, which is in the front; it is closed by a plate-iron door, turning

round. Above the door there is a chimney, to let the sulphureous and arsenical fumes fly off, which escape out of the hearth, without annoying the workmen. This chimney leads to horizontal flues, in which the arsenious acid is condensed.

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1467



1468



When the ore is sufficiently calcined, as is shown by its ceasing to exhale vapours, it is taken out, and exposed for some days to the action of the air, which decomposes the sulphurets, or changes them into sulphate of iron. It is next put into a tub filled with water, and stirred with a wooden rake, and left to settle. The sulphate of iron, which is precipitated, is allowed to settle, and the water is poured off into a tub. The residue is washed by precipitation with water, and the water is allowed to settle, and the water is poured off into a tub. The residue is washed by precipitation with water, and the water is allowed to settle, and the water is poured off into a tub.

of the rake; 2. by separating the larger conglomerate pebbles from the smaller pure ones; picking, stamping, and washing, on a kind of *sleeping-tables*. See *METALLURGY*, figs. 910, 911.

The tin ores of Cornwall and Devonshire are all reduced within the counties where they are mined, as the laws prohibit their exportation out of them. Private interests suffer no injury from this prohibition; because the vessels which bring the fuel from Wales, for smelting these ores, return to Swansea and Neath loaded with copper ores.

The smelting-works belong in general to individuals who possess no tin mines, but who purchase at the cheapest rate the ores from the mining proprietors. The ores are appraised according to their contents in metal, and its fineness; conditions which they determine by the following mode of assay. When a certain number of bags of ore, of nearly the same quality, are brought to the works, a small sample is taken from each bag, and the whole are well blended. Two ounces of this average ore are mixed with about 4 per cent. of ground coal, put into an open earthen crucible, and heated in an air furnace (in area about 10 inches square) till reduction takes place. As the furnace is very hot when the crucible is introduced, the assay is finished in about a quarter of an hour. The metal thus revived, is poured into a mould, and what remains in the crucible is pounded in a mortar, that the grains of tin may be added to the ingot.

This method, though imperfect in a chemical point of view, serves the smelter's purpose, as it affords him a similar result to what he would get on the great scale. A more exact assay would be obtained by fusing, in a crucible lined with hard-rammed charcoal, the ore mixed with 5 per cent. of ground glass of borax. To the crucible a gentle heat should be applied during the first hour, then a strong heat during the second hour, and, lastly, an intense heat for a quarter of an hour. This process brings out from 4 to 5 per cent. more tin than the other; but it has the inconvenience of reducing the iron, should any be present; which by subsequent solution in nitric acid will be readily shown. This assay would be too tedious for the smelter, who may have occasion to try a great many samples in one day.

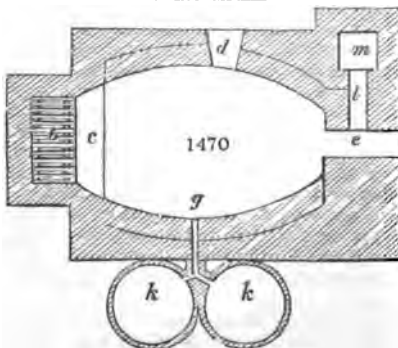
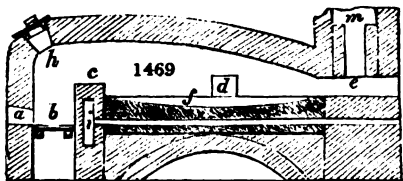
The smelting of tin ores is effected by two different methods:—

In the first, a mixture of the ore with charcoal is exposed to heat on the hearth of a reverberatory furnace fired with coal.

In the second, the tin ore is fused in a blast furnace, called a blowing-house, supplied with wood charcoal. This method is practised in only a few works, in order to obtain a very pure quality of tin, called *grain tin* in England, and *étain en larmes* in France; a metal required for certain arts, as dyeing, &c. This method is applied merely to stream tin.

In the *smelting-houses*, where the tin is worked in reverberatories, two kinds of furnaces are employed; the reduction and the refining furnaces.

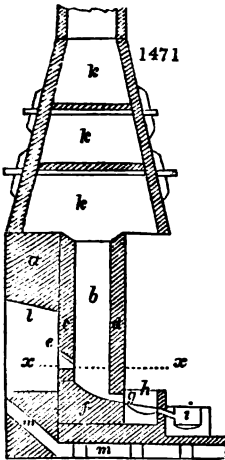
Figs. 1469, 1470. represent the furnaces for smelting tin at St. Austle, in Cornwall; the former being a longitudinal section, the latter a ground plan.



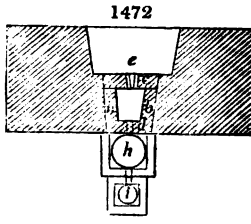
through which pitcoal is laid upon the grate *b*; *c* is the fire-bridge; *d*, the door for introducing the ore; *e*, the door through which the ore is worked upon the hearth *f*; *g*, the stoke-hole; *h*, an aperture in the vault or roof, which is opened at the discharge of the waste schlich, to secure the free escape of the fumes up the chimney; *i, i*, air channels, for admitting cold air under the fire-bridge and the sole of the hearth, with the view of protecting them from injury by the intensity of the heat above. *k, k*, are basins into which the melted tin is drawn off; *l*, the flue; *m*, the chimney, from 35 to 50 feet high. The roasted and washed schlich is mixed with small coal or culm, along with a little slaked lime, or fluor spar, as a flux; each charge of ore amounts to from 15 to 24 cwt., and contains from 60 to 70 per cent. of metal.

Fig. 1471. represents in a vertical section through the tuyère, and fig. 1472. in a horizontal section, in the dotted line *x, x*, of fig. 1471., the fur-

nace employed for smelting tin at the Erzgebirge mines, in Saxony. *a*, are the furnace pillars, of gneiss; *b*, *b*, are shrouding or casing walls; *c*, the tuyère wall; *d*, front wall, both of granite; as also the tuyère *e*. *f*, the sole-stone, of granite, hewn out basin-shaped; *g*, the eye, through which the tin and slag are drawn off into the fore-hearth *h*; *i*, the stoke-hearth; *k*, *k*, the light ash chambers; *l*, the arch of the tuyère; *m*, *m*, the common flue, which is placed under the furnace and the hearths, and has its outlet under the vault of the tuyère.



In the smelting furnaces at Geyer the following dimensions are preferred: — Length of the tuyère wall, 11 inches; of the breast wall, 11 inches; depth of the furnace, 17 inches. High chimney-stalks are advantageous where a great quantity of ores is to be reduced, but not otherwise.



The refining furnaces are similar to those which serve for reducing the ore; only, instead of a basin of reception, they have a refining basin placed alongside, into which the tin is run. This basin is about 4 feet in diameter, and 32 inches deep; it consists of an iron pan, placed over a grate, in which a fire may be kindled. Above this pan

there is a turning gib, by means of which a billet of wood may be thrust down into the bath of metal, and kept there by wheeling the gibbet over it, lowering a rod, and fixing it in that position.

The works in which the blast furnaces are employed, are called *blowing-houses*. The smelting furnaces are 6 feet high, from the bottom of the crucible (concave hearth) to the throat, which is placed at the origin of a long and narrow chimney, interrupted by a chamber, where the metallic dust, carried off by the blast, is deposited. This chamber is not placed vertically over the furnace; but the lower portion of the chimney has an oblique direction from it. The furnace is lined with an upright cylinder of cast iron, coated internally with loam, with an opening in it for the blast. This opening, which corresponds to the lateral face opposite to the charging side, receives a *tuyère*, in which the nozzles of two cylinder single bellows, driven by a water-wheel, are planted. The *tuyère* opens at a small height above the sole of the furnace. On a level with the sole, the iron cylinder presents a slope, below which is the hemispherical basin of reception, set partly beneath the interior space of the furnace, and partly without. Near the corner of the building there is a second basin of reception, larger than the first, which can discharge itself into the former by a sloping gutter. Near this basin there is another, for the refining operation. These are all made either of brick or cast iron.

The quality of the average ground-tin ore prepared for smelting is such, that 20 parts of it yield from 12½ to 13 of metallic tin, (62½ to 65 per cent.) The treatment consists of two operations, *smelting* and *refining*.

First operation; deoxidization of the ore, and fusion of the tin. — Before throwing the ore into the smelting furnace, it is mixed with from one-fifth to one-eighth of its weight of *blind coal*, in powder, called *cum*; and a little slaked lime is sometimes added, to render the ore more fusible. These matters are carefully blended, and damped with water, to render the charging easier, and to prevent the blast from sweeping any of it away at the commencement. From 12 to 16 cwt. are introduced at a charge; and the doors are immediately closed and luted, while the heat is progressively raised. Were the fire too strong at first, the tin oxide would unite with the quartz of the gangue, and form an enamel. The heat is applied for 6 or 8 hours, during which the doors are not opened; of course the materials are not stirred. By this time the reduction is, in general, finished; the door of the furnace is removed, and the melted mass is worked up to complete the separation of the tin from the scoriae, and to ascertain if the operation be in sufficient forwardness. When the reduction seems to be finished, the scoriae are taken out at the same door, with an iron rake, and divided into three sorts; those of the first class *A*, which constitute at least three-fourths of the whole, are as poor as possible, and may be thrown away; the scoriae of the second class *B*, which contain some small grains of tin, are sent to the stamps; those of the third class *C*, which are last removed from the surface of the bath of tin, are set apart, and re-smelted, as containing a considerable quantity of metal in the form of grain tin. These scoriae are in small quantity. The stamp slag contains fully 5 per cent. of metallic tin.

As soon as the scoriae are cleared away, the channel is opened which leads to the

basin of reception, into which the tin consequently flows out. Here it is left for some time, that the scorix which may be still mixed with the metal, may separate, in virtue of the difference of their specific gravities. When the tin has sufficiently settled, it is lifted out with ladles, and poured into cast-iron moulds, in each of which a bit of wood is fixed, to form a hole in the ingot, for the purpose of drawing it out when it becomes cold.

Refining of tin. — The object of this operation is to separate from the tin, as completely as possible, the metals reduced and alloyed along with it. These are, principally, iron, copper, arsenic, and tungsten; to which are joined, in small quantities, some sulphurets and arseniurets that have escaped decomposition, a little unreduced oxide of tin, and also some earthy matters which have not passed off with the scorix.

Liquation. — The refining of tin consists of two operations; the first being a liquation, which, in the interior, is effected in a reverberatory furnace, similar to that employed in smelting the ore. (figs. 1469, 1470.) The blocks being arranged on the hearth of the furnace, near the bridge, are moderately heated; the tin melts, and flows away into the refining-basin; but, after a certain time, the blocks cease to afford tin, and leave on the hearth a residuum, consisting of a very ferruginous alloy.

Fresh tin blocks are now arranged on the remains of the first; and thus the liquation is continued till the refining-basin be sufficiently full, when it contains about 5 tons. The residuums are set aside, to be treated as shall be presently pointed out.

Refining proper. — Now begins the second part of the process. Into the tin-bath, billets of green wood are plunged, by aid of the gibbet above described. The disengagement of gas from the green wood produces a constant ebullition in the tin; bringing up to its surface a species of froth, and causing the impurest and densest parts to fall to the bottom. That froth, composed almost wholly of the oxides of tin and foreign metals, is successively skimmed off, and thrown back into the furnace. When it is judged that the tin has boiled long enough, the green wood is lifted out, and the bath is allowed to settle. It separates into different zones, the upper being the purest; those of the middle are charged with a little of the foreign metals; and the lower are much contaminated with them. When the tin begins to cool, and when a more complete separation of its different qualities cannot be looked for, it is lifted out in ladles, and poured into cast-iron moulds. It is obvious, that the order in which the successive blocks are obtained, is that of their purity; those formed from the bottom of the basin being usually so impure, that they must be subjected anew to the refining process, as if they had been directly smelted from the ore.

The refining operation takes 5 or 6 hours; namely, an hour to fill the basin, three hours to boil the tin with the green wood, and from one to two hours for the subsidence.

Sometimes a simpler operation, called *tossing*, is substituted for the above artificial ebullition. To effect it, a workman lifts some tin in a ladle, and lets it fall back into the boiler, from a considerable height, so as to agitate the whole mass. He continues this manipulation for a certain time; after which, he skims with care the surface of the bath. The tin is afterwards poured into moulds, unless it be still impure. In this case, the separation of the metals is completed by keeping the tin in a fused state in the boiler for a certain period, without agitation; whereby the upper portion of the bath (at least one-half) is pure enough for the market.

The moulds into which the tin blocks are cast, are usually made of granite. Their capacity is such, that each block shall weigh a little more than three hundred weight. This metal is called block tin. The law requires them to be stamped or *coined* by public officers, before being exposed to sale. The purest block tin is called refined tin.

The treatment just detailed gives rise to two stanniferous residuums, which have to be smelted again. These are —

1. The scorix *a* and *c*, which contain some granulated particles of tin.
2. The dross found on the bottom of the reverberatory furnace, after re-melting the tin to refine it.

The scorix *c*, are smelted without any preparation; but those marked *a*, are stamped in the mill, and washed, to concentrate the tin grains; and from this rich mixture, called *prillion*, smelted by itself, a tin is procured of very inferior quality. This may be readily imagined, since the metal which forms these granulations is what, being less fusible than the pure tin, solidified quickly, and could not flow off into the metallic bath.

Whenever all the tin blocks have thoroughly undergone the process of liquation, the fire is increased, to melt the less fusible residuary alloy of tin with iron and some other metals, and this is run out into a small basin, totally distinct from the refining basin. After this alloy has reposed for some time, the upper portion is lifted out into block moulds, as impure tin, which needs to be refined anew. On the bottom and sides of the basin there is deposited a white, brittle alloy, with a crystalline fracture, which contains so great a proportion of foreign metals, that no use can be made of it. About $3\frac{1}{2}$ tons of coal are consumed in producing 2 of tin.

Smelting of tin by the blast furnace. — This mode of reduction employs only wood

charcoal, and its object is to obtain tin of the maximum purity to which it can be brought by manufacturing processes. The better ores of the stream-works, and the finer tin sands, are selected for this operation. The washings being always well performed, the oxide of tin is exempt from every arsenical or sulphureous impurity, and is associated with nothing but a little hematite. It is therefore never calcined.

The smelting is effected without addition; only, in a few cases, some of the residuary matters of a former operation are added to the ore. About a ton and six-tenths of wood charcoal are burned for one ton of fine smelted tin. The only rule is, to keep the furnace always full of charcoal and ore. The revived tin is received immediately in the first basin; then run off into the second, where it is allowed to settle for some time. The scoriae that run off into the first basin, are removed as soon as they fix. These scoriae are divided into two classes; namely, such as still retain tin oxide, and such as hold none of the metal in that state, but only in granulations. The metallic bath is divided, by repose, into horizontal zones, of different degrees of purity; the more compound and denser matters falling naturally to the bottom of the basin. The tin which forms the superior zones, being judged to be pure enough, is transversed by ladles into the refining basin, previously heated, and under which, if it is of cast-iron, a moderate fire is applied. The tin near the bottom of the receiving basin is always laded out apart, to be again smelted; sometimes, indeed, when the furnace is turning out very impure tin, none of it is transversed into the second basin; but the whole is cast into moulds, to be again treated in the blast furnace.

In general they receive no other preparation, but the green wood ebullition, before passing into the market. Sometimes, however, the block of metal is heated till it becomes brittle, when it is lifted to a considerable height, and let fall, by which it is broken to pieces, and presents an agglomeration of elongated grains or *tears*; whence it is called *grain tin*.

On making a comparative estimate of the expense by the *blowing-house* process, and by the reverberatory furnace, it has been found that the former yields about 66 per cent. of tin, in smelting the stream or alluvial ore, whose absolute contents are from 75 to 78 parts of metal in the hundred. One ton of tin consumes a ton and six-tenths of wood charcoal, and suffers a loss of 15 per cent. In working with the reverberatory furnace, it is calculated that ore whose mean contents by an exact analysis are 70 per cent., yields 65 per cent. on the great scale. The average value of tin ore, as sold to the smelter, is 50 pounds sterling per ton; but it fluctuates, of course, with the market prices. In 1824, the ore of inferior quality cost 30*l.*, while the purest sold for 60*l.* One ton of tin, obtained from the reverberatory furnace, cost —

| | | | | | | |
|---|---|---|---|---------|----|---|
| 1½ tons of ore, worth | - | - | - | £75 | 0 | 0 |
| 1½ tons of coals, at 10 <i>s.</i> per ton | - | - | - | 0 | 17 | 6 |
| Wages of labour, interest on capital, &c. | - | - | - | 3 | 0 | 0 |
| | | | | 78 17 6 | | |

On comparing these results with the former, we perceive that in a *blowing-house* the loss of tin is 15 per cent., whereas it is only 5 in the reverberatory furnace. The expense in fuel is likewise much less relatively in the latter process; for only 1½ tons of coals are consumed for one ton of tin; while a ton and six-tenths of wood charcoal are burned to obtain the same quantity of tin in the blowing-house; and it is admitted that one ton of wood charcoal is equivalent to two tons of coal, in calorific effect. Hence every thing conspires to turn the balance in favour of the reverberatory plan. The operation is also, in this way, much simpler, and may be carried on by itself. The scoriae, besides, from the reverberatory hearth, contain less tin than those derived from the same ores treated with charcoal by the blast, as is done at Altenberg. It must be remembered, however, that the grain tin procured by the charcoal process is reckoned to be finer, and fetches a higher price; a superiority partly due to the purity of the ore reduced, and partly to the purity of the fuel.

To test the quality of tin, dissolve a certain weight of it with heat in muriatic acid; should it contain arsenic, brown-black flocks will be separated during the solution, and arseniuretted hydrogen gas will be disengaged, which, on being burned at a jet, will deposit the usual gray film of metallic arsenic upon a white saucer held a little way above the flame. Other metals present in the tin, are to be sought for, by treating the above solution with nitric acid of spec. grav. 1.16, first in the cold, and at last with heat and a small excess of acid. When the action is over, the supernatant liquid is to be decanted off the peroxidized tin, which is to be washed with very dilute nitric acid, and both liquors are to be evaporated to dissipate the acid excess. If, on the addition of water to the concentrated liquor, a white powder falls, it is a proof that the tin contains bismuth; if on adding sulphate of ammonia, a white precipitate appears, the tin contains lead; water of ammonia added to supersaturation, will occasion reddish-brown

locks, if iron is present; and on evaporating the supernatant liquid to dryness, the copper will be obtained.

The uses of tin are very numerous. Combined with copper, in different proportions, it forms bronze, and a series of other useful alloys; for an account of which see COPPER. With iron, it forms tin-plate; with lead, it constitutes pewter, and solder of various kinds (see LEAD). Tin-foil coated with quicksilver makes the reflecting surface of glass mirrors. (See GLASS.) Nitrate of tin affords the basis of the scarlet dye on wool, and of many bright colours to the calico-printer and the cotton-dyer. (See SCARLET and TIN MORDANTS.) A compound of tin with gold gives the fine crimson and purple colours to stained glass and artificial gems. See PURPLE OF CASSIUS. Enamel is made by fusing oxide of tin with the materials of flint glass. This oxide is also an ingredient in the white and yellow glazes of pottery-ware.

The Exhibition contained a series of specimens, illustrative of an improved process for dressing ores of tin containing wolfram (the tungstate of iron and manganese, invented by Mr. R. Oxland, of Plymouth, for the separation of the wolfram from the ores of the Drake Walls tin mine, on the Cornish side of the river Tamar. This process is now in regular operation at the mine. In consequence of the specific gravity of wolfram, which is from 7.100 to 7.500, being greater than that of the black tin of the mines or the pure native oxide of tin, which is only from 6.3 to 7.0, it has been found impossible to separate the wolfram from the tin oxide by the usual mechanical process of washing in a stream of water. This led to the necessity of adopting the patent chemical process explained, with the description of the series of specimens.

No. 1. "Tin witts": the ore obtained from the stamp-floors, where, subsequently to its having been crushed or stamped down to a suitable size, it has been washed in a stream of water, in order to separate the earthy particles with which it was associated. The clean "witts" contain native oxide of tin; black tin or resin tin, and wolfram with iron and arsenical pyrites, generally containing some copper. In the course of washing, the "witts" are sorted into different parcels, according to the size of the particles, and are known as jigged, marked A; flucan, B; smalls or "smales," C; slime, D; roughs or rows, E. The "witts" are calcined in a reverberatory furnace, usually constructed of fire-bricks throughout. The calcination is continued until all the sulphur and arsenic is evolved.

The residue No. 2, contains black tin or native tin oxide, peroxide of iron, wolfram, some sulphate of copper, and a small quantity of earthy matter. By a series of washing operations on the burning house floors, the peroxide of iron, sulphate of copper, and earthy matters, are removed, and the product obtained is No. 3, which consists of oxide of tin, with most of the wolfram. The process is in the next place employed for the removal of the wolfram. Its proportion having been ascertained by analysis, a quantity of sulphate of soda or salt cake is mixed with the ore, sufficient to supply a slight excess equivalent of soda for the quantity of tungstic acid present; but with the sulphate of soda must be mixed sufficient coal dust or charcoal to afford carbon or carburetted hydrogen, for the decomposition of the sulphuric acid and the conversion of sulphate of soda into sulphide of sodium. The mixture is exposed to heat on the bed of the furnace described below; a smoky or reducing flame is at first employed, but after the whole of the charge has been at a red heat for some time an oxidating flame is necessary to complete the operation. Thus the sulphate of soda is first converted into sulphide of sodium, then the tungstic acid of the wolfram combines with the soda, producing tungstite of soda, setting the sulphur free as sulphurous acid, and leaving the iron in the condition of a light, finely-divided peroxide.

The product No. 4, is drawn from the furnace into the wrinkle or chamber beneath, and is thence removed whilst still hot into tanks containing water, which quickly dissolves the tungstate of soda. The solution is run off into receivers, and the residue is removed to the burning house floors, where by a series of washings the peroxide is removed, and the native oxides of tin obtained pure and ready for the smelting-house as seen in No. 5: an ore which had fetched only 42*l.* per ton has by this operation been so much improved in quality as to obtain 56*l.* per ton.

The tungstate of soda, No. 6, is obtained in the crystalline form by the evaporation to the crystallizing point of the solution in which it was separated from the tin. It is proposed to be used as a substitute for stannite of soda, a mordant for dyeing purposes.

Tungstic acid, No. 7, may be employed for the same purpose or for the manufacture of tungstate of the tungstous oxide with soda, a compound much resembling gold.

The tungstate of lead, No. 8, and tungstate of lime, No. 9, are good white pigments (manufactured from the tungstate of soda), from which was also obtained the metallic tungsten, No. 10, and sulphuret of tungsten, No. 11. The former is for use in the manufacture of metallic alloys; the latter has been proposed as a substitute for black

lead. The furnace is composed in the usual manner, excepting that a cast-iron bed has been employed to prevent the loss that would arise from the reaction of the silica of the bricks, the soda and the tin oxide on each other. The fire after passing over the bed is made to circulate beneath it before passing away to the chimney.

In all great smelting works of this class, the smoke rising from the furnace is slightly charged with noxious vapours, containing besides other poisonous matters a large quantity of lead; many attempts have been made to obviate this nuisance; and the system adopted by the exhibitor has been found to be very successful.

An oblong building in solid masonry, about 90 feet in height, is divided by a partition wall into two chambers, having a tall chimney or tower adjoining, which communicates with one of the chambers at the bottom. The smoke from the various furnaces, 8 in number and about 100 yards distance from the condenser, is carried by separate flues into a large chamber; from thence by a large flue it enters the first chamber of the condenser at the very bottom, and is forced upwards in a zigzag course towards the top, passing four times through a shower of water, constantly percolating from a pierced reservoir at the summit of the tower. The smoke is again compelled to filter a fifth time through a cube of coke some two feet square, through which a stream of water filters downwards, and which is confined to its proper limits by a vertical grating of wood.

The smoke having reached the top is now opposite the passage into the second or vacuum chamber. This is termed the exhausting chamber, and is about 5 feet by 7 feet inside, and 30 or more feet in height. On its summit is fixed a large reservoir supplied by an ample stream of water, always maintaining a depth of 6 to 10 inches.

The bottom of this tank is of iron having several openings or slots, 12 in number and about an inch in width, and extending across the whole area of the reservoir, communicating directly with the chamber beneath. On this iron plate works a hydraulic side-plate with openings corresponding in one position with those in the reservoir. This plate receives a horizontal reciprocating motion from a water wheel or other power, driven by means of a connecting rod and crank.

In the middle of every stroke the openings in the plate correspond with those in the bottom of the reservoir, and a powerful body of water falls as a shower bath, the whole length of the vacuum chamber, and in doing so sweeps the entire inside area, carrying with it every particle of insoluble matter held suspended in the vapours coming from the furnaces.

The atmospheric pressure of course acts in alternate strokes, as a blast at the furnace mouths, and causes a draught sufficiently strong to force the impure vapours through the various channels in connection with the water, the wet coke, and exhausting chamber, until it passes, purified and inert, into the atmosphere.

The water saturated with particles of lead, &c., held in mechanical solution, finally passes into great dykes or reservoirs, excavated for the purpose, and there deposits its rich charge of metal.

The results of this arrangement are most apparent and beneficial to the surrounding neighbourhood. Formerly the noxious fumes passing from the shafts of the furnaces poisoned the neighbourhood; the heather was burnt up, vegetation destroyed, and no animal could graze, or bird feed near the spot. Now the heather is seen in luxuriance close around the establishment, sheep graze within a stone's throw of the chimney base, and game on all sides take shelter.

The county of Cornwall is the most important mineral district of the United Kingdom, for the number of its metalliferous minerals, many of which are not found in any other part of the island. At a very early period of our history, mines were worked around the sea-coasts of Cornwall, of which the evidences are still to be seen at Tolpeddin-Penwith, near the Land's End; in Gwennap, near Truro; and at Cadwith, near the Lizard Point. The traditionary statements, that the Phœnicians traded for tin with the Britons in Cornwall, are very fairly supported by corroborative facts; and it is not improbable that the *Ictes*, or *Iktis*, of the ancients was St. Michael's Mount near Penzance.

In the reign of King John, the mines of the western portion of England appear to have been principally in the hands of the Jews. The modes of working must have been very crude, and their metallurgical processes exceedingly rough. From time to time remains of furnaces, called *Jews' houses*, have been discovered, and small blocks of tin, known as *Jews' tin*, have not unfrequently been found in the mining localities.

Till a comparatively recent date, tin was the only metal which was sought for; and in many cases the mines were abandoned when the miners came to the "yellows," that is, the yellow sulphuret of copper. The greatest quantity of tin has been produced by "streaming" (as washing the debris in the valleys is termed); and this variety, called "stream tin," produces the highest price in the market.

The conditions under which these deposits occur are curious and instructive. At the

Carnon Tin Stream Works, north of Falmouth, the rounded pebbles of tin are found at a depth of about 50 feet from the surface, beneath the bottom of an estuary, where trees are discovered in their place of growth, together with human skulls, and the remains of deer, amidst the vegetable accumulation which immediately covers the stanniferous beds. According to Mr. Henwood's measurement, the section presents first about 50 feet of schlich and gravel; then a bed of 18 inches in thickness of wood, leaves, nuts, &c., resting on the tin ground, composed of the debris of quartz, slate, and granite, and the tin ore. At the Pentuan Works, near St. Austell, similar deposits occur, proving a material alteration in the level, during the period expended in the formation of this deposit. Tin is also worked out of the lode in many parts, the ore occurring both in the slate and granite formations. The modes of "dressing" the tin ore, preparing it for the smelter, and the process of smelting, were illustrated in the Exhibition.

There has been a remarkable uniformity in the quantity of tin produced in Cornwall, during a long period, as will be seen from the following table:—

| Years. | Tons. | Prices per cwt. | |
|--------|-------|-----------------|----|
| | | £ | s. |
| 1750 | 1,600 | | |
| 1760 | 1,800 | | |
| 1770 | 2,000 | | |
| 1780 | 1,800 | 3 | 0 |
| 1790 | 2,000 | 3 | 15 |
| 1800 | 1,500 | 5 | 0 |
| 1810 | 1,400 | 7 | 0 |
| 1820 | 1,700 | 3 | 5 |
| 1830 | 3,500 | 3 | 0 |
| 1840 | 5,000 | 3 | 15 |

The produce of this metal within the last few years has been as follows:—

| Years. | Tons. |
|--------|--------|
| 1844 | 7,507 |
| 1845 | 7,739 |
| 1846 | 8,945 |
| 1847 | 10,072 |
| 1848 | 10,176 |
| 1849 | 10,719 |

Since 1838 the quantity cannot be accurately ascertained, the trade in tin being in the hands of a few, and the purchases of ore being usually made by private contract.—
See METALLIC STATISTICS.

Tin coating of iron and zinc, by Mr. Morris Stirling's patent process. The first improvement in coating metals or alloys of metals with other metals or their alloys, relates to coating iron with tin or its alloys after the iron has been coated with zinc. For this purpose the sheet, plate, or other form of iron, previously coated with zinc, either by dipping or by depositing from solutions of zinc, is taken, and after cleaning the surface by washing in acid or otherwise, so as to remove any oxide or foreign matter which would interfere with the perfect and equal adhesion of the more fusible metal or alloy with which it is to be coated, it is dipped into melted tin, or any suitable alloy thereof, in a perfectly fluid state, the surface of which is covered with any suitable material, such as fatty or oily matters, or the chloride of tin, so as to keep the surface of the metal free from oxidation; and such dipping is to be conducted in a like manner to the process of making tin plate or of coating iron with zinc. When a fine surface is required, the plates or sheets of iron coated with zinc may be passed between polished rolls (as already described) before and after, or either before or after they are coated with tin or other alloy thereof. It is preferred in all cases to use for the coating pure tin of the description known as grain tin.

Another part of the invention consists in covering either (wholly or in part) zinc and its alloys with tin, and such of its alloys as are sufficiently fusible. To effect this, the

following is the process adopted : — A sheet or plate of zinc (by preference such as has been previously rolled, both on account of its ductility and smoothness) is taken, and after cleaning its surface by hydrochloric or other acid, or otherwise, it is dried, and then dipped or passed in any convenient manner through the melted tin, or fusible alloy of tin. It is found desirable to heat the zinc, as nearly as may be, to the temperature of the melted metal, previous to dipping it, and to conduct the dipping, or passing through, as rapidly as is consistent with thorough coating of the zinc, to prevent as much as possible the zinc becoming alloyed with the tin. It is recommended also that the tin or alloy of tin should not be heated to a higher temperature than is necessary for its proper fluidity. The metal thus coated, if in the form of sheet, plate, or cake, can then be rolled down to the required thickness; and should the coating of tin or alloy be found insufficient or imperfect, the dipping is to be repeated as above described, and the rolling also, if desired, either for smoothing the surface or further reducing the thickness.

Another part of the invention consists in coating lead or its alloys with tin or alloys thereof. The process is to be conducted as before described for the coating of zinc, and the surface of lead is to be perfectly clean. The lead may, like the zinc, be dipped more than once, either before or after being reduced in thickness by rolling. The hydraulic press may be advantageously employed in the process of coating lead or its alloys with tin or its alloys; and this process is already practised and well understood, as applied to the coating of lead pipe with tin; it is only necessary to remark that a die or orifice must be used of such length and width as will allow an ingot cake or sheet to be formed. On both sides of this cake or sheet, melted tin is to be poured into a suitable receptacle, as is well understood in the making of pipe; but where only one side or portion of the cake, ingot, or sheet is to be tinned, a partition or division should be placed to confine the melted tin, so that it shall only be applied to that portion of the lead which is required to be tinned. Where a smooth surface is required, the cake or other form of lead is to be passed, while in a heated state, through a collar of suitable hard and smooth material, such as hardened steel or iron, kept as cool as may be. Where a strong coating of tin is required, the lead so coated is to be passed through melted tin. Such coated lead, or its alloys, may be reduced by rolling; and where the lead so coated is to be reduced to extreme thickness, the further coating is advantageously given after the coated metal has been reduced to some extent by rolling. Any number of additional coatings may, in a similar manner, be given, according to the purpose for which the coated lead is required. In coating lead or its alloys with tin, it is recommended that, for purposes where a surface of lead is to be avoided, pure tin should be used. When lead is alloyed with antimony, zinc, tin, or other metal, to render the lead more hard than lead in its ordinary state, the tin coating may also be somewhat hardened by alloying with zinc or other suitable hardening metal.

Lead and its alloys may also be coated with tin or its alloys of greater fusibility than the metal to be coated, as follows : — The cake, or other form to be coated, is to be placed as soon after casting as may be in an iron, gun metal or other suitable mould, or if this cannot be conveniently done, the surfaces are to be cleansed and prepared, for the reception of the coating metal, either by previously tinning the surface, or by applying other suitable material to facilitate the union, as heretofore practised. At one end of the mould is to be attached chambers, of more than sufficient capacity to contain the quantity of metal to be used for coating, which may with advantage form an integral part of the mould, or such chamber may surround the mould, and by one or more sluices or valves in such chamber or chambers, the melted metal is to be allowed to run on to the surface of the metal to be coated, when the metal is to be coated on one side only. When it is intended to coat the metal on both sides, the vertical position will be found convenient, and the coating metal is to be formed into a chamber or chambers attached to the mould, and to be introduced into the lower part of the mould by opening a sluice or valve, sufficient space being left on each side of the cake or other form to allow of the coating being of the required thickness; the sluice or valve should be of nearly the width or length of the cake or other form, and the melted metal should be allowed to flow into the bottom of the mould, (Mr. Stirling here observes, that he is aware that lead has been previously coated with tin by pouring tin upon the lead, and also by pressure, and that he does not therefore claim the coating of lead by such means.) The surface of the plate or cake ought to be smooth and true, and the mould, if horizontal, to be perfectly so, and if upright, quite perpendicular, so as to insure in either case an equal footing. The surface of the lead should also be clean, and it will be found advantageous to raise its temperature to a point somewhat approaching the melting point of tin or of the alloy employed for coating, as by this means the union of the two metals is facilitated. It is recommended also, that a somewhat larger quantity of the tin or alloy than is necessary for the coating of the lead or other metal, or alloy, should be employed, and that when the requisite thickness of coating has been given, the flow of the coating metal be stopped, as by this means the impurities on the surface of the tin will be prevented passing

through the opening on to the surface of the cake: the chamber or chambers should be kept at such temperature as to ensure the proper fluidity of the coating metal. Zinc and its alloys may in like manner be coated with tin and its alloys, by employing a like apparatus to that just described for coating lead and its alloys, and it constitutes a part of this invention thus to coat zinc. The coating of zinc with tin, however, is not claimed, that having been done by pouring on tin.

Another part of the invention consists in coating zinc and its alloys with tin and its alloys by pressure. For this purpose Mr. Stirling takes a suitable piece of zinc or alloyed zinc (by preference previously rolled), and when it is desired to coat it on both sides with tin or alloyed tin, of sufficient dimensions to completely cover the zinc. He then subjects the metal so placed to pressure, to obtain perfect contact; and for this purpose, when making sheets, he employs rolls, and rolls out the two metals to the extent desired.

The last part of the invention relates to the employment of zinc when welding together plates or other forms of iron, which is principally applicable when piling iron. Thin sheet zinc, placed between the layers, has been found to answer well; but the use of calamine, in the form of powder or paste, is preferred. In the latter case the paste may be formed with water, to which a small quantity of borax may be added; the paste can then be applied with a brush or otherwise, to the surface of the plates or other forms of iron. Additional stiffness and toughness are produced by this process, and cold short iron is believed to be more particularly benefitted thereby.

TINCAL, crude borax.

TINCTORIAL MATTER. One of the most curious and valuable facts ascertained upon this subject, is, that madder kept in casks, in a warm place, undergoes a species of fermentation, which, by ripening or rather deoxidizing the colouring matter, increases its dyeing power by no less than from 20 to 50 per cent. See M. H. Schlumberger's memoir read to the *Société Industrielle de Mulhausen*, 24 November, 1837.

TINCTURE is a title used by apothecaries to designate alcohol, in a somewhat dilute state, impregnated with the active principles of either vegetable or animal substances.

TIN-GLASS, is a name of bismuth.

TIN MORDANTS, for dyeing scarlet:—

Mordant a, as commonly made by the dyers, is composed of 8 parts of aquafortis, 1 part of common salt or sal ammoniac, and 1 of granulated tin. This preparation is very uncertain.

Mordant a.—Pour into a glass globe with a long neck, 3 parts of pure nitric acid at 30° B.; and 1 part of muriatic acid at 17°; shake the globe gently, avoiding the corrosive vapours, and put a loose stopper in its mouth. Throw into this nitro-muriatic acid, one-eighth of its weight of pure tin, in small bits at a time. When the solution is complete, and settled, decant it into bottles, and close them with ground stoppers. It should be diluted only when about to be used.

Mordant c, by Dambourney.—In two drams Fr. (144 gra.) of pure muriatic acid, dissolve 18 grains of Malacca tin. This is reckoned a good mordant for brightening or fixing the colour of peachwood.

Mordant d, by Hellot.—Take 8 ounces of nitric acid, diluted with as much water; dissolve in it half an ounce of sal ammoniac, and 2 drams of nitre. In this acid solution dissolve one ounce of granulated tin of Cornwall, observing not to put in a fresh piece till the preceding be dissolved.

Mordant e, by Scheffer.—Dissolve one part of tin in four of a nitro-muriatic acid, prepared with nitric acid diluted with its own weight of water, and one thirty-secondth of sal ammoniac.

Mordant f, by Poerner.—Mix one pound of nitric acid with one pound of water, and dissolve in it an ounce and a half of sal ammoniac. Stir it well, and add, by very slow degrees, two ounces of tin turned into thin ribbons upon the lathe.

Mordant g, by Berthollet.—Dissolve in nitric acid of 30° B., one-eighth of its weight of sal ammoniac, then add by degrees one-eighth of its weight of tin, and dilute the solution with one-fourth of its weight of water.

Mordant k, by Dambourney.—In one dram (72 gra.) of muriatic acid at 17°, one of nitric acid at 30°, and 18 grains of water, dissolve, slowly and with some heat, 18 grains of fine Malacca tin.

Mordant l, is the birch bark prescribed by Dambourney.—This bark, dried and ground, is said to be a very valuable substance for fixing the otherwise fugitive colours produced by woods, roots, archil, &c.

TIN-PLATE. The only alloy of iron interesting to the arts, is that with tin, in the formation of *tin-plate*, or *white-iron*.

The sheet iron intended for this manufacture is refined with charcoal instead of coke, subsequently rolled to various degrees of thinness, and cut into rectangles of different

sizes, by means of a sheering-machine driven by a water-wheel, which will turn out 100 boxes a day, or four times the number cut by hand labour. The first step towards tinning is to free the metallic surface from every particle of oxide or impurity, for any such would inevitably prevent the iron from alloying with the tin. The plates are next bent separately by hand into a saddle or Δ shape, and ranged in a reverberatory oven, so that the flame may play freely among them, and heat them to redness. They are then plunged into a bath, composed of four pounds of muriatic acid diluted with three gallons of water, for a few minutes, taken out and drained on the floor, and once more exposed to ignition in a furnace, whereby they are *sealed*, that is to say, cast their scales. The above bath will suffice for sealing 1800 plates. When taken out, they are beat level and smooth on a cast-iron block, after which they appear mottled blue and white, if the *scaling* has been thoroughly done. They are next passed through *chilled* rolls or cast-iron cylinders, rendered very hard by being cast in thick iron moulds, as has been long practised by the Scotch foundries in casting bushes for cart-wheels. After this process of *cold rolling*, the plates are immersed, for ten or twelve hours, in an acidulous lye, made by fermenting bran-water, taking care to set them separately on edge, and to turn them at least once, so that each may receive a due share of the operation. From this lye-steep they are transferred into a leaden trough, divided by partitions, and charged with dilute sulphuric acid. Each compartment is called a *hole* by the workmen, and is calculated to receive about 225 plates, the number afterwards packed up together in a *box*. In this liquid they are agitated about an hour, till they become perfectly bright, and free from such black spots as might stain their surface at the time of immersion. This process, called pickling, is both delicate and disagreeable, requiring a good workman, at high wages. The temperature of the two last steeps should be at least 90° or 100° Fahr., which is kept up by stoves in the apartments. The plates are finally scoured with hemp and sand in a body of water, and then put aside for use in a vessel of pure water, under which they remain bright and free from rust for many months, a very remarkable circumstance.

The *finishing* follows these preparatory steps. A range of rectangular cast-iron pots is set over a fire-flue in an apartment called the *stow*, the workmen stationing themselves opposite to the narrow ends. The first rectangle in the range is the tin-pot; the second is the wash-pot, with a partition in it; the third is the grease-pot; the fourth is the pan, grated at bottom; the fifth is the list-pot, and is greatly narrower than any of the rest: they are all of the same length.

The prepared plates, dried by rubbing bran upon them, are first immersed one by one in a pot filled with melted tallow alone, and are left there for nearly an hour. They are thence removed, with the adhering grease, into pot No. 1., filled with a melted mixture of block and grain tin, covered with about four inches of tallow, slightly carbonized. This pot is heated by a fire, playing under its bottom and round its sides, till the metal becomes so hot as nearly to inflame the grease. Here about 340 plates are exposed, upright, to the action of the tin for an hour and a half, or more, according to their thickness. They are next lifted out, and placed upon an iron grating, to let the superfluous metal drain off; but this is more completely removed in the next process, called *washing*.

Into the wash-pot, No. 2., filled with melted *grain* tin, the workman puts the above plates, where the heat detaches the ribs, and drops. There is a longitudinal partition in it, for keeping the drop of tin that rises in washing from entering the vessel where the last dip is given. Indeed, the metal in the wash-pot, after having acted on 60 or 70 boxes, becomes so foul, that the weight of a block (300 cwt.) of it, is transferred into the tin-pot, No. 1., and replaced by a fresh block of grain tin. The plates being lifted out of the wash-pot, with tongs held in the left hand of the workman, are scrubbed on each side with a peculiar hempen brush, held in his right hand, then dipped for a moment in the hot tin, and forthwith immersed in the adjoining grease-pot, No. 3. This requires manual dexterity; and though only three-pence be paid for brushing and tin-washing 225 plates, yet a good workman can earn six shillings and three-pence in twelve hours, by putting 5625 plates through his hands. The final tin-dip is useful to remove the marks of the brush, and to make the surface uniformly bright. To regulate the temperature of the tallow-pot, and time during which the plates are left in it, requires great skill and circumspection on the part of the workman. If kept in it too long, they would be deprived to a certain extent of their silvery lustre; and if too short, streaks of tin would disfigure their surface. As a thick plate retains more heat after being lifted out of the washing-pot, it requires a proportionally cooler grease-pot. This pot has pins fixed within it, to keep the plates asunder; and whenever the workman has transferred five plates to it, a boy lifts the first out into the cold adjoining pan, No. 4.; as soon as the workman transfers a sixth plate, the boy removes the second; and so on. The manufacture is completed by removing the wire of tin left on the under edge of the plates, in consequence of their vertical position in the preceding operations. This is the

business of the *list-boy*, who seizes the plates when they are cool enough to handle, and puts the lower edge of each, one by one, into the list-pot, No. 5., which contains a very little melted tin, not exceeding a quarter of an inch in depth. When he observes the wire-edge to be melted, he takes out the plate, and, striking it smartly with a thin stick, detaches the superfluous metal, which leaves merely a faint stripe where it lay. This mark may be perceived on every tin-plate in the market.

The plates are finally prepared for packing up in their boxes, by being well cleansed from the tallow, by friction with bran.

Mr. Thomas Morgan obtained a patent, in September, 1829, for clearing the sheet-iron plates with dilute sulphuric acid in a *hole*, instead of *scaling* them in the usual way previous to their being cold rolled, annealed, and tinned; whereby, he says, a better article is produced at a cheaper rate.

Crystallized tin-plate, see *MOIRÉ METALLIQUE*. It would seem that the acid merely lays bare the crystalline structure really present on every sheet, but masked by a film of redundant tin. Though this showy article has become of late years vulgarized by its cheapness, it is still interesting in the eyes of the practical chemist. The English tin-plates marked *r*, answer well for producing the *Moirée*, by the following process. Place the tin-plate, slightly heated, over a tub of water, and rub its surface with a sponge dipped in a liquor composed of four parts of aquafortis, and two of distilled water, holding one part of common salt or sal ammoniac in solution. Whenever the crystalline spangles seem to be thoroughly brought out, the plate must be immersed in water, washed either with a feather or a little cotton (taking care not to rub off the film of tin that forms the feathering), forthwith dried with a low heat, and coated with a lacquer varnish, otherwise it loses its lustre in the air. If the whole surface is not plunged at once in cold water, but if it be partially cooled by sprinkling water on it, the crystallization will be finely variegated with large and small figures. Similar results will be obtained by blowing cold air through a pipe on the tinned surface, while it is just passing from the fused to the solid state; or a variety of delineations may be traced, by playing over the surface of the plate with the pointed flame of a blowpipe.

The following TABLE shows the several sizes of tin-plates, the marks by which they are distinguished, and their current wholesale prices in London:—

| Names. | Sizes. | No. in a Box. | Weight of each Box. | Marks on the Boxes. | Prices per Box, in | |
|----------------------|-------------------------------------|---------------|---------------------|---------------------|--------------------|-------|
| | | | | | 1823. | 1838. |
| | Inches. | | Cwt. qrs. lbs. | | s. | s. d. |
| Common, No. 1. - | 13 $\frac{1}{2}$ by 10 | 225 | 1 0 0 | CI. | 47 | 35 0 |
| Ditto 2. - | 13 $\frac{1}{2}$ — 9 $\frac{1}{2}$ | - - | 0 3 21 | CH. | 45 | 33 6 |
| Ditto 3. - | 12 $\frac{1}{2}$ — 9 $\frac{1}{2}$ | - - | 0 3 16 | CHH. | 43 | 32 9 |
| Cross, No. 1. - | 13 $\frac{1}{2}$ — 10 | - - | 1 1 0 | XI. | 53 | 40 2 |
| Two crosses, 1. - | - - - | - - | 1 1 21 | XX. | 58 | 43 2 |
| Three crosses, 1. - | - - - | - - | 1 2 14 | XXX. I. | 63 | 47 0 |
| Four crosses, 1. - | - - - | - - | 1 3 7 | XXXX. I. | | |
| Common doubles - | 16 $\frac{1}{2}$ — 12 $\frac{1}{2}$ | 100 | 0 3 21 | CD. | 64 6 | 48 6 |
| Cross doubles - | - - - | - - | 1 0 14 | XD. | 73 6 | 56 0 |
| Two cross do. - | - - - | - - | 1 1 7 | XXD. | 81 | 60 6 |
| Three cross do. - | - - - | - - | 1 2 0 | XXXD. | 88 6 | 65 0 |
| Four cross do. - | - - - | - - | 1 2 21 | XXXXD. | | |
| Com. small doubles | 5 — 11 | 200 | 1 2 0 | CSD. | 69 | 51 6 |
| Cross do. do. - | - - - | - - | 1 2 21 | XSD. | 75 | 56 0 |
| Two cross do. - | - - - | - - | 1 3 14 | XXSD. | 80 | 59 6 |
| Three cross do. - | - - - | - - | 2 0 7 | XXXSD. | | |
| Four cross do. - | - - - | - - | 2 1 0 | XXXXSD. | | |
| Waster's com. No. 1. | 3 $\frac{1}{2}$ — 10 | 225 | 1 0 0 | WCI. | 44 | 32 9 |
| Do. cross, 1. | ditto | - - | 1 1 0 | WCI. | 50 | 47 3 |

These are the cash prices of one wholesale warehouse in Thames-street; an immediately adjoining warehouse charges fully 1s. more upon the standard CI, and proportionally upon others.

Tin plate working in the Exhibition. Jackson, W., Birmingham, manufacturer. Anvil for planishing tin plate. Hammers assorted for tin and copper work. Crease-iron or wiring stake for tin. General swage, to hold different tools, for beading tin. Bick-iron for tin plate, and side stake for tin or copper work. Bottom stake, for planishing copper. Pair of stock shears and hand shears for cutting tin, copper, &c. Model of a raising machine for raising dish covers, 1 $\frac{1}{2}$ inch in scale.

Many of the requisites for the tin plate making are enumerated in the above collection of articles, and though "raising" by means of "spinning" and stamping has to a great extent superseded the older methods of tin plate working, the polished anvil stakes or back iron, with their corresponding planishing-faced hammers of various forms, cannot yet be dispensed with. In the new mode of production seam-soldering is entirely avoided. Spinning imparts to tin goods a considerable degree of firmness and solidity with denseness of texture. Moulding is still necessary in the manufacture of certain articles; to effect this, stakes, anvils, and wages must be put into requisition. Dish covers were originally formed by hammering out of flat sheets of metal; many of them here are raised by the stamp, and present a brilliant polish. Tin-plate making and tool making for the same give employment to hundreds of artizans in and round Birmingham.

TITANIUM, is a rare metal, discovered by Klaproth, in menachanite, in 1794. It has been detected since in the form of small cubes of a copper-red colour in some of the blast furnaces in Yorkshire. According to Hassenfratz, its presence in small quantity does not impair the malleability of iron. It is very brittle, so hard as to scratch steel, and very light, having a specific gravity of only 5.3. It will not melt in the heat of any furnace, nor dissolve, when crystallized, even in nitro-muriatic acid; but only when in fine powder. By calcination with nitre, it becomes oxygenated, and forms titanate of potassa. Traces of this metal may be detected in many irons, both wrought and cast. The principal ores of titanium are *sphene*, common and foliated, *rutile*, *iserine*, *menachanite*, and *octahedrite* or *pyramidal titanium ore*. None of them has been hitherto applied to any use.

TOBACCO. It is said that the name tobacco was given by the Spaniards to the plant, because it was first observed by them at Tabasco, or Tabaco, a province of Yucatan in Mexico. In 1560, Nicot, the French ambassador to Portugal, having received some tobacco from a Flemish merchant, showed it, on his arrival in Lisbon, to the grand prior, and, on his return to France, to Catherine of Medicis, whence it has been called Nicotiana by the botanists. Admiral Sir Francis Drake having, on his way home from the Spanish Main, in 1586, touched at Virginia, and brought away some forlorn colonists, is reported to have first imported tobacco into England. But, according to Lobel, this plant was cultivated in Britain before the year 1570; and was consumed by smoking in pipes by Sir Walter Raleigh, and companions, so early as the year 1584.

The plants are hung up to dry during four or five weeks; taken down out of the sheds in damp weather, for in dry they would be apt to crumble into pieces; stratified in heaps, covered up, and left to sweat for a week or two, according to their quality and the state of the season; during which time they must be examined frequently, opened up, and turned over, lest they become too hot, take fire, or run into putrefactive fermentation. This process needs to be conducted by skilful and attentive operatives. An experienced negro can form a sufficiently accurate judgment of the temperature, by thrusting his hand down into the heap.

The tobacco thus prepared, or often without fermentation, is sent into the market; but, before being sold, it must undergo the inspection of officers, appointed by the state with very liberal salaries, who determine its quality, and brand an appropriate stamp upon its casks, if it be sound; but if it be bad, it is burned.

Our respectable tobacconists are very careful to separate all the damaged leaves, before they proceed to their preparation, which they do by spreading them in a heap upon a stone pavement, watering each layer in succession, with a solution of sea salt, of spec. grav. 1.107, called *sauce*, till a ton or more be laid; and leaving their principles to react on each other for three or four days, according to the temperature, and the nature of the tobacco. It is highly probable that ammonia is the volatilizing agent of many odours, and especially of those of tobacco and musk. If a fresh green leaf of tobacco be crushed between the fingers, it emits merely the herbaceous smell common to many plants; but if it be triturated in a mortar, along with a little quicklime or caustic potash, it will immediately exhale the peculiar odour of snuff. Now analysis shows the presence of muriate of ammonia in this plant, and fermentation serves further to generate free ammonia in it; whence, by means of this process, and lime, the odoriferous vehicle is abundantly developed. If, on the other hand, the excess of alkaline matter in the tobacco of the shops be saturated by a mild dry acid, as the tartaric, its peculiar aroma will entirely disappear.

Tobacco contains a great quantity of an azotized principle, which by fermentation produces abundance of ammonia; the first portions of which saturate the acid juices of the plant, and the rest serve to volatilize its odorous principles. The salt water is useful chiefly in moderating the fermentation, and preventing it from passing into the putrefactive stage; just as salt is sometimes added to saccharine worts in tropical countries, to temper the fermentative action. The sea salt, or concentrated sea water, which contains some muriate of lime, tends to keep the tobacco moist, and is therefore preferable to pure chloride of sodium for this purpose. Some tobacconists mix molasses with the salt *sauce*, and ascribe to this addition the violet colour of the *macouba* snuff of Mar-

tinique; and others add a solution of extract of liquorice. The following prescription is that used by a skilful manufacturer:— In a solution of the liquorice juice, a few figs are to be boiled for a couple of hours; to the decoction, while hot, a few bruised anise-seeds are to be added, and when cold, common salt to saturation. A little silent spirit of wine being poured in, the mixture is to be equally, but sparingly, sprinkled with the rose of a watering-pot, over the leaves of the tobacco, as they are successively stratified upon the preparation floor.

The fermented leaves, being next stripped of their middle ribs by the hands of children, are sorted anew, and the large ones are set apart for making cigars. Most of the tobaccos on sale in our shops are mixtures of different growths; one kind of smoking tobacco, for example, consists of 70 parts of Maryland and 30 of meagre Virginia; and one kind of snuff consists of 80 parts of Virginia, and 30 parts of either Mumesfort or Warwick. The Maryland is a very light tobacco, in thin yellow leaves; that of Virginia is in large brown leaves, unctuous or somewhat gluey on the surface, having a smell somewhat like the figs of Malaga; that of Havannah is in brownish light leaves, of an agreeable and rather spicy smell; it forms the best cigars. The Carolina tobacco is less unctuous than the Virginian; but in the United States it ranks next to the Maryland. The shag tobacco is dried to the proper point upon sheets of copper.

Tobacco is cut into what is called shag tobacco by knife-edged chopping stamps, a machine somewhat similar to that represented under METALLURGY, fig. 903. For grinding the tobacco leaves into snuff, conical mortars are employed, somewhat like that used by the Hindoos for grinding sugar-canes; but the sides of the snuff-mill have sharp ridges from the top to near the bottom.

Mr. L. W. Wright obtained a patent in August, 1827, for a tobacco-cutting machine, which bears a close resemblance to the well-known machines with revolving knives, for cutting straw into chaff. The tobacco, after being squeezed into cakes, is placed upon a smooth bed within a horizontal trough, and pressed by a follower and screws to keep it compact. These cakes are progressively advanced upon the bed, or fed in, to meet the revolving blades. The speed of the feeding-screw determines the degree of fineness of the sections or particles into which the tobacco is cut.

I was employed some years ago by the Excise to analyze a quantity of snuff, seized on suspicion of having been adulterated by the manufacturer. I found it to be largely drugged with pearl-shales, and to be thereby rendered very pungent, and absorbent of moisture; an economical method of rendering an effete article at the same time active and aqueous.

According to the recent analysis of Posset and Reimann, 10,000 parts of tobacco-leaves contain 6 of the peculiar chemical principle *nicotins*; 1 of *nicotianine*; 287 of slightly bitter extractive; 174 of gum, mixed with a little malic acid; 26.7 of a green resin; 26 of vegetable albumen; 104.8 of a substance analogous to gluten; 51 of malic acid; 12 of malate of ammonia; 4.8 of sulphate of potassa; 6.3 of chloride of potassium; 9.5 of potassa, which had been combined with malic and nitric acids; 16.6 of phosphate of lime; 24.2 of lime, which had been combined with malic acid; 8.8 of silica; 496.9 of fibrous or ligneous matter; traces of starch; and 88.28 of water.

Nicotins is a transparent colourless liquid, of an alkaline nature. It may be distilled in a retort plunged into a bath heated to 290° Fahr. It has a pricking, burning taste, which is very durable; and a pungent disagreeable smell. It burns by means of a wick, with the diffusion of a vivid light, and much smoke. It may be mixed with water in all proportions. It is soluble also in acetic acid, oil of almonds, alcohol, and ether, but not in oil of turpentine. It acts upon the animal economy with extreme violence; and in the dose of one drop it kills a dog. It forms salts with the acids. About one part of it may be obtained by very skilful treatment from one thousand of good tobacco.

| | | |
|-----------------------------|------|--------------------------------------|
| Virginia leaf costs in bond | 3½d. | per lb., the duty is 1,100 per cent. |
| Ditto strips | 5½d. | " " 700 " |
| Kentucky leaf | 2½d. | " " 1,200 " |
| Ditto strips | 4½d. | " " 800 " |
| Havannah cigars | 8s. | " " 119 " |
| Manilla cheroots | 6s. | " " 150 " |
| East India cheroots | 1s. | " " 900 " |
| Negrohead and Cavendish | 6d. | " " 1,800 " |

Rates of duty on tobacco in foreign countries:—

| | Per English Pound. | Per English Pound. |
|---------------------------------------|-------------------------------------|--------------------|
| Austria—leaf tobacco | 2d. | |
| Belgium ditto | ½d. | |
| Bremen ditto, ½ per cent. ad valorem. | ½d. | |
| Denmark leaves and stems | ½d. | |
| Prussia | | |
| Saxony | | |
| Bavaria | | |
| Brunswick | | |
| Württemberg | | |
| Frankfort on the Maine | | |
| Zoll-Verrein States | 2d. | |
| Other German States | | |
| Hamburgh | ½ per cent. ad valorem. | ½d. |
| Holland | ½ per cent. ad valorem. | |
| Ditto, cigars | | 2d. |
| Ionian islands, leaf stems | | 2d. |
| Ditto manufactured | | 3d. |
| Russia | 30 per cent. ad valorem on foreign. | |
| Sweden and Norway | | about 1d. |

A strict royal monopoly (*régie*) exists in Austria Proper, France, Sardinia, the Duchies of Parma and Lucca, and the Grand Duchy of Tuscany; and in Portugal, Spain, Naples, and the States of the Church, the licence to manufacture is periodically sold to companies, which regulate the prices of tobacco as they please. It will be found that the situation of all these countries where the monopolies and high prices are kept up, is nearly the same, as to illicit trade in tobacco, as in England. No measure short of a reduction of the duty to 1s. per lb. can put a stop to it.

The following analysis of 10,000 parts of fresh tobacco, by Posselt and Reimann, will show the exceeding complexity of this substance:—

| | | | |
|--|-------|---|---------|
| Nicotine - - - - - | 6 | Chloride of potassium - - - - - | 6.3 |
| Nicotianine - - - - - | 1 | Potash combined with malic and nitric acids - - - | 9.5 |
| Extractive matter, slightly bitter - - - - - | 287 | Phosphate of lime - - - - - | 16.6 |
| Gum with a little malate of lime - - - - - | 174 | Lime in union with malic acid - - - - - | 34.2 |
| Green resin - - - - - | 267 | Silica - - - - - | 5.8 |
| Vegetable albumen - - - - - | 26.0 | Woody fibre - - - - - | 499.9 |
| Substance analogous to gluten - - - - - | 104.8 | Water (traces of starch) - - - - - | 8828.0 |
| Malic acid - - - - - | 81.0 | | |
| Malate of ammonia - - - - - | 13.0 | | |
| Sulphate of potash - - - - - | 4.8 | | 10000.0 |

In *Silliman's Journal*, vol. vii. p. 2., a chemical examination of tobacco is given by Dr. Covell, which shows its components to have been but imperfectly represented in the above German analysis. He found, 1. gum; 2. a viscid slime, equally soluble in water and alcohol, and precipitable from both by subacetate of lead; 3. tannin; 4. gallic acid; 5. chlorophyle (leaf-green); 6. a green pulverulent matter, which dissolves in boiling water, but falls down again when the water cools; 7. a yellow oil, possessing the smell, taste, and poisonous qualities of tobacco; 8. a large quantity of a pale yellow resin; 9. nicotine; 10. a white substance, analogous to morphia, soluble in hot, but hardly in cold, alcohol; 11. a beautiful orange-red dye stuff, soluble only in acids; it deflagrates in the fire, and seems to possess neutral properties; 12. nicotianine. In the infusion and decoction of the leaves of tobacco, little of this substance is found; but after they are exhausted with ether, alcohol, and water, if they be treated with sulphuric acid, and evaporated near to dryness, crystals of sulphate of nicotianine are obtained. Ammonia precipitates the nicotianine from the solution in the state of a yellowish white, soft powdering matter, which may be kneaded into a lump, and is void of taste and smell, as all its neutral saline combinations also are: its most characteristic property is that of forming soluble and uncrystallisable compounds with vegetable acids.

According to Buchner, the seeds of tobacco yield a pale yellow extract to alcohol, which contains a compound of nicotine and sugar. *Repertorium für die Pharmacie*, vol. xxxiii.

MM. Henry and Boutron Charlard found in

| | |
|--------------------------------------|--------------------------------|
| 1000 parts of Cuba tobacco - - - - - | 8.64 of nicotine; |
| Maryland - - - - - | 5.28 |
| Virginia - - - - - | 10.00 |
| Ile et Vilaine - - - - - | 11.20 |
| Lot et Garonne - - - - - | 8.20; quantities from 12 to 19 |

times more than were obtained by Posselt and Reimann.

The total quantities of tobacco retained for home consumption in 1842, amounted to nearly 17,000,000 pounds. Professor Schleiden gives a singular illustration of the quantity of tobacco consumed. North America alone produces annually upwards of 200,000,000 of pounds of tobacco. The combustion of this mass of vegetable material would yield about 340,000,000 pounds of carbonic acid gas, so that the yearly produce of carbonic acid gas, from tobacco smoking alone, cannot be estimated at less than 1,000,000,000 pounds; a large contribution to the annual demand for this gas made upon the atmosphere by the vegetation of the world.

Tobacco imported into the United Kingdom, viz.—unmanufactured, in 1850, 35,166,358 lbs.; in 1851, 31,061,953 lbs.;—manufactured, and snuff, in 1850, 1,557,518 lbs.; in 1851, 2,331,886 lbs. Retained for home consumption, unmanufactured, in 1850, 27,538,104 lbs.; in 1851, 27,853,390 lbs.;—manufactured, and snuff, in 1850, 196,681 lbs.; in 1851, 209,588 lbs. Duty received,—on unmanufactured tobacco, in 1850, 4,337,258*l.*; in 1851, 4,386,910*l.*; on manufactured tobacco, and snuff, in 1850, 92,873*l.*; in 1851, 98,858*l.*

TOBACCO-PIPES. The practice of smoking tobacco has become so general in many nations as to render the manufacture of tobacco-pipes a considerable branch of industry. Some seek in the inhalation of tobacco-smoke a pleasurable narcotism; others imagine it to be beneficial to their health; but, in general, smoking is merely a dreamy resource against ennui, which ere long becomes an indispensable stimulus. The filthy-

ness of this habit, the offensive odour which persons under its influence emit from their mouths and clothes, the stupor it too often occasions, as well as the sallow complexion, black or carious teeth, and impaired digestion, all prove the great consumption of tobacco to be akin in evil influence upon mankind to the use of ardent spirits.

Tobacco-pipes are made of a fine-grained plastic white clay, to which they have given the name. It is worked with water into a thin paste, which is allowed to settle in pits, or it may be passed through a sieve, to separate the siliceous or other stony impurities; the water is afterwards evaporated till the clay becomes of a doughy consistence, when it must be well kneaded to make it uniform. Pipe-clay is found chiefly in the Isle of Purbeck and Dorsetshire. It is distinguished by its perfectly white colour, and its great adhesion to the tongue after it is baked; owing to the large proportion of alumina which it contains.

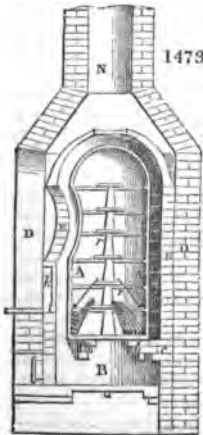
A child fashions a ball of clay from the heap, rolls it out into a slender cylinder upon a plank, with the palms of his hands, in order to form the stem of the pipe. He sticks a small lump to the end of the cylinder for forming the bowl; which having done, he lays the pieces aside for a day or two, to get more consistence. In proportion as he makes these rough figures, he arranges them by dozens on a board, and hands them to the pipemaker.

The pipe is finished by means of a folding brass or iron mould, channelled inside, of the shape of the stem of the bowl, and capable of being opened at the two ends. It is formed of two pieces, each hollowed out like a half-pipe, cut as it were lengthwise; and these two jaws, when brought together, constitute the exact space for making one pipe. There are small pins in one side of the mould, corresponding to holes in the other, which serve as guides for applying the two together with precision.

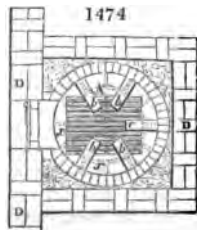
The workman takes a long iron wire, with its end oiled, and pushes it through the soft clay in the direction of the stem, to form the bore, and he directs the wire by feeling with his left hand the progress of its point. He lays the pipe in the groove of one of the jaws of the mould, with the wire sticking in it; applies the other jaw, brings them smartly together, and unites them by a clamp or vice, which produces the external form. A lever is now brought down, which presses an oiled stopper into the bowl of the pipe, while it is in the mould, forcing it sufficiently down to form the cavity; the wire being meanwhile thrust backwards and forwards so as to pierce the tube completely through. The wire must become visible at the bottom of the bowl, otherwise the pipe will be imperfect. The wire is now withdrawn, the jaws of the mould opened, the pipe taken out, and the redundant clay removed with a knife. After drying for a day or two, the pipes are scraped, polished with a piece of hard wood, and the stems being bent into the desired form, they are carried to the baking kiln, which is capable of firing fifty gross in a day from 8 to 12 hours. A workman and a child can easily make five gross of pipes in a day.

No tobacco-pipes are so highly prized as those made at Natolia, in Turkey, out of meerscham, a somewhat plastic magnesian stone, of a soft greasy feel, which is formed into pipes after having been softened with water. It becomes white and hard in the kiln.

A tobacco-pipe kiln should diffuse an equal heat to every part of its interior, while it excludes the smoke of the fire. The crucible, or large sagger, *A, A*, *figs.* 1473. and



1474., is a cylinder, covered in with a dome. It is placed over the fireplace *a*, and enclosed within a furnace of ordinary brickwork *b, b*, lined with fire-bricks *x, x*. Between this lining and the cylinder, a space of about 4 inches all round is left for the circulation of the flame. There are 12 supports or ribs between the cylinder and the furnace lining, which form so many flues, indicated by the dotted lines *x*, in *fig.* 1474. (the dotted circle representing the cylinder). These ribs are perforated with occasional apertures, as shown in *fig.* 1473., for the purpose of connecting the adjoining flues; but the main



bearing of the hollow cylinder is given by five piers *b, b, c*, formed of bricks projecting over and beyond each other. One of these piers *c*, is placed at the back of the fireplace, and the other four at the sides *b, b*. These project nearly into the centre, in order to support and strengthen the bottom; while the flues pass up between them, unite at the top of the cylinder in the dome *L*, and discharge the smoke by the chimney *N*.

The lining *r, z, z*, of the chimney is

open on one side to form the door, by which the cylinder is charged and discharged. The opening is permanently closed as high as *k*, *fig.* 1473., by an iron plate plastered over with fire-clay; above this it is left open, and shut merely with temporary brick-work while the furnace is going. When this is removed, the furnace can be filled or emptied through the opening, the cylindrical crucible having a correspondent aperture in its side, which is closed in the following ingenious way, while the furnace is in action. The workman first spreads a layer of clay round the edge of the opening: he then sticks the stems of broken pipes across from one side to the other, and plasters up the interstices with clay, exactly like the lath-and-plaster work of a ceiling. The whole of the cylinder, indeed, is constructed in this manner, the bottom being composed of a great many fragments of pipe stems, radiating to the centre; these are coated at the circumference with a layer of clay. A number of bowls of broken pipes are inserted in the clay; in these other fragments are placed upright to form the sides of the cylinder. The ribs round the outside, which form the flues, are made in the same way, as well as the dome *l*; by which means the cylindrical case may be made very strong, and yet so thin as to require little clay in the building, a moderate fire to heat it, while it is not apt to split asunder. The pipes are arranged within, as shown in the figure, with their bowls resting against the circumference, and their ends supported on circular pieces of clay *r*, which are set up in the centre for that purpose. Six small ribs are made to project inwards all round the crucible, at the proper heights to support the different ranges of pipes, without having so many resting on each other as to endanger their being crushed by the weight. By this mode of distribution, the furnace may contain 50 gross, or 7200 pipes, all baked within 8 or 9 hours; the fire being gradually raised, or damped if occasion be, by a plate partially slid over the chimney top.

TODDY, *Sura*, *Mee-ra*, sweet juice. — The proprietors of coco-nut plantations in the peninsula of India, and in the Island of Ceylon, instead of collecting a crop of nuts, frequently reap the produce of the trees by extracting sweet juice from the flower-stalk. When the flowering branch is half shot, the toddy-drawers bind the stock round with a young coco-nut leaf in several places, and beat the spadix with a short baton of ebony. This beating is repeated daily for ten or twelve days, and about the end of that period a portion of the flower-stalk is cut off. The stump then begins to bleed, and an earthen vessel (*chatty*) or a calabash is suspended under it, to receive the juice, which is by the Europeans called *toddy*.

A thin slice is taken from the stump daily, and the toddy is removed twice a day. A coco-nut frequently pushes out a new *spadix* once a month; and after each *spadix* begins to bleed, it continues to produce freely for a month, by which time another is ready to supply its place. The old *spadix* continues to give a little juice for another month, after which it withers; so that there are sometimes two pots attached to a tree at one time, but never more. Each of these *spadices*, if allowed to grow, would produce a bunch of nuts from two to twenty. Trees in a good soil produce twelve bunches in the year; but when less favourably situated, they often do not give more than six bunches. The quantity of six English pints of toddy is sometimes yielded by a tree daily.

Toddy is much in demand as a beverage in the neighbourhood of villages, especially where European troops are stationed. When it is drunk before sunrise, it is a cool, delicious, and particularly wholesome beverage; but by eight or nine o'clock fermentation has made some progress, and it is then highly intoxicating.*

TOLU, is a brownish-red balsam, extracted from the stem of the *Myroxylon toluiferum*, a tree which grows in South America. It is composed of resin, oil, and benzoic acid. Having an agreeable odour, it is sometimes used in perfumery. It has a place in the *Materia Medica*, but for what good reason I know not.

TOMBAC, is a white alloy of copper.

TONKA BEAN, the fruit of the *Dipterix odorata*, affords a concrete crystalline volatile oil (*stearoptene*), called *coumarins* by the French. It is extracted by digestion with alcohol, which dissolves the *stearoptene* and leaves a fat oil. It has an agreeable smell, and a warm taste. It is fusible at 122° Fahrenheit, and volatile at higher heats.

TOOTH FACTORY. Pure crystallized quartz is calcined by a moderate heat. When taken from the fire it is thrown immediately into cold water, which breaks it into numberless pieces. The larger pieces are broken into smaller, and the whole put into a mill, which is itself made of quartz. Here the pieces of calcined quartz are ground up into fine powder. Next fluor spar, free from all impurities, is ground up in like manner into a fine powder. Artificial teeth are composed of two parts,

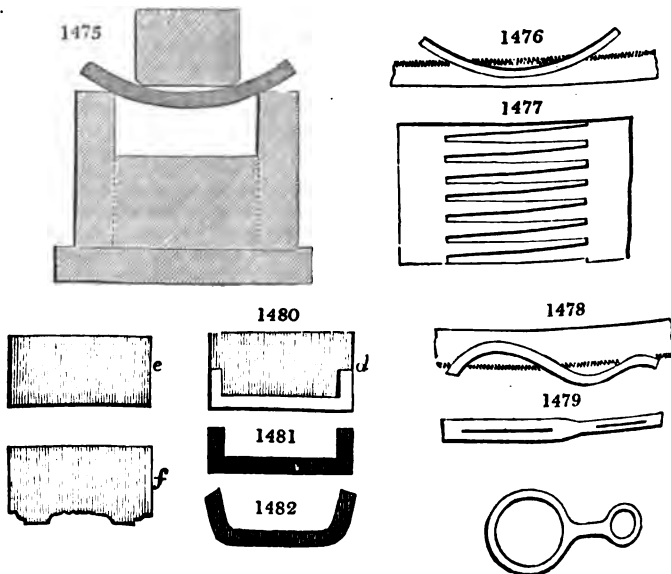
* Contributions to the History of the Coco-nut Tree. By Henry Marshall, Esq., Deputy Inspector of Hospitals.

called the body and enamel. The body of the tooth is made first, the enamel is added last.

The next step is to mix together nearly equal parts, by weight, of the powdered spar and quartz. This mixture is again ground to a greater fineness. Certain metallic oxides, as of tin, are now added to it, for the purpose of producing an appropriate colour, and water and china clay to make it plastic and give it consistence. This mixture resembles soft paste, which is transferred to the hands of females, who are engaged in filling moulds with it, or otherwise working upon it. After the paste has been moulded into proper shape, two small platina rivets are inserted near the base of each tooth, for the purpose of fastening it (by the dentist), to a plate in the mouth. They are now transferred to a furnace, where they are "cured," as it is technically called; that is, half baked or hardened. The teeth are now ready to receive the enamel, which is done by women; it consists of spar and quartz which has been ground, pulverized, and reduced to the state of a soft paste, which is evenly spread over the half baked body of the tooth by means of a delicate brush. The teeth must be next subjected to an intense heat. They are put into ovens, lined with platina and heated by a furnace, in which the necessary heat is obtained. The baking process is superintended by a workman, who occasionally removes a tooth to ascertain whether those within have been sufficiently baked. This is indicated by the appearance of the tooth. When they are done, the teeth are placed in jars ready for use. An experiment tests the hardness of these artificial teeth. One of them taken indiscriminately out from a jar-full is driven without breaking into a fine board, until it is even with the surface of the wood.

TOPAZ. See LAPIDARY.

TORTOISE-SHELL, or rather scale, a horny substance, that covers the hard strong covering of a bony contexture, which encloses the *Testudo imbricata*, Linn. The lamellæ or plates of this tortoise are thirteen in number, and may be readily separated from the bony parts by placing fire beneath the shell, whereby they start asunder. They vary in thickness from one-eighth to one-quarter of an inch, according to the age and size of the animal, and weigh from 5 to 25 pounds. The larger the animal, the better is the shell. This substance may be softened by the heat of boiling water; and if compressed in this state by screws in iron or brass moulds, it may be bent into any shape. The moulds being then plunged in cold water, the shell becomes fixed in the form imparted by the mould. If the turnings or filings of tortoise-shell be subjected skilfully to gradually increased compression between moulds immersed in boiling water, compact objects of any desired ornamental figure or device may be produced. The soldering of two pieces of scale is easily effected, by placing their edges together, after they are nicely filed to one bevel, and then squeezing them strongly between the long flat jaws of hot iron pincers, made somewhat like a hairdresser's curling-tongs. The pincers should be



strong, thick, and just hot enough to brown paper slightly, without burning it. They may be soldered also by the heat of boiling water, applied along with skilful pressure. But in whatever way this process is attempted, the surfaces to be united should be made very smooth, level, and clean; the least foulness, even the touch of a finger, or breathing upon them, would prevent their coalescence. See HORN.

Tortoise-shell is manufactured into various objects, partly by cutting out the shapes and partly by agglutinating portions of the shell by heat. When the shell has become soft by dipping it in hot water, and the edges are in the cleanest possible state without grease, they are pressed together with hot flat tongs, and then plunged into cold water, to fix them in their position. The teeth of the larger combs are parted in their heated state, or cut out with a thin frame saw, while the shell, equal in size to two combs, with their teeth interlaced, as in *fig. 1475.*, is bent like an arch in the direction of the length of the teeth, as in *fig. 1476.* The shell is then flattened, the points are separated with a narrow chisel or *pricker*, and the two combs are finished, while flat, with coarse single-cut files and triangular scrapers. They are finally warmed, and bent on the knee over a wooden mould, by means of a strap passed round the foot, just as a shoemaker fixes his last. Smaller combs of horn and tortoise-shell are parted, while flat, by an ingenious machine, with two chisel-formed cutters placed obliquely, so that each cut produces one tooth. See Rogers's comb-cutting machine, *Trans. Soc. Arts*, vol. xlix. part 2., since improved by Mr. Kelly. In making the frames for eye-glasses, spectacles, &c. the apertures for the glasses were formerly cut out to the circular form with a tool something like a carpenter's centre-bit, or with a crown saw in the lathe. The discs so cut out were used for inlaying in the tops of boxes, &c. This required a piece of shell as large as the front of the spectacle; but a piece one third of the size will now suffice, as the eyes are *strained or pulled.* A long narrow piece is cut out, and two slits are made in it with a saw. The shell is then warmed, the apertures are pulled open, and fastened upon a taper triblet of the appropriate shape; as illustrated by *figs. 1477, 1478, and 1479.* The groove for the edge of the glass is cut with a small circular cutter, or sharp-edged saw, about three eighths or half an inch in diameter; and the glass is sprung in when the frame is expanded by heat.

In making tortoise-shell boxes, the round plate of shell is first placed centrally over the edge of the ring, as in *fig. 1480.*: it is slightly squeezed with the small round edge-block *g*, and the whole press is then lowered into the boiling water: after immersion for about half an hour, it is transferred to the bench, and *g* is pressed entirely down, so as to bend the shell into the shape of a saucer, as at *fig. 1481.*, without cutting or injuring the material; and the press is then cooled in a water-trough. The same processes are repeated with the die *d*, which has a rebate turned away to the thickness of the shell, and completes the angle of the box to the section *fig. 1482.*, ready for finishing in the lathe. It is always safer to perform each of these processes at two successive boilings and coolings. Two thin pieces are cemented together by pressure with the die *e*, and a device may be given by the engraved die *f.* See *Holtzapffel's Turning and Mechanical Manipulation*, vol. i. p. 129.

TOUCH-NEEDLES, and TOUCH-STONE, are means of ascertaining the quality of gold trinkets. See ASSAY.

TOW. See FLAX.

TRAGACANTH, GUM. (*Gomme adracante*, Fr.; *Traganth*, Germ.) See GUM.

TRAVERTINO. See TUFA.

TREACLE, is the viscid brown uncrystallizable syrup which drains from the sugar-refining moulds. Its specific gravity is generally 1.4, and it contains upon an average 75 per cent. of solid matter, by my experiments.

TRIPOLI (*Terre poverre*, Fr.; *Tripel*, Germ.); rotten-stone; is a mineral of an earthy fracture, a yellowish gray or white colour, composition impalpably fine, meagre to the touch, does not adhere to the tongue, and burns white. Its analogue, the *Polierschiefer*, occurs in thin flat foliated pieces, of the above colours, occasionally striped; soft, absorbent of water; spec. grav. 1.9 to 2.2.

M. Ehrenberg has shown that both of these friable homogeneous rocks, which consist almost entirely of silica, are actually composed of the exuviae or rather the skeletons of infusoria (*animalcula*) of the family of *Barcellaria*, and the genera *Cocconema*, *Gonphonema*, &c. They are recognised with such distinctness in the microscope, that their analogies with living species may be readily traced; and in many cases there are no appreciable differences between the living and the petrified. The species are distinguished by the number of partitions or transverse lines upon their bodies. The length is about $\frac{1}{14}$ of a line. M. Ehrenberg made his observations upon the tripolis of Billen in Bohemia, of Santafiora in Tuscany, of the Isle of France, and of Francisbad, near Eger.

The meadow iron ore (*Fer limoneux des marais*) is composed almost wholly of the *Gaellonella ferruginea*. Most of these infusoria are lacustrine; but others are marine, particularly the *tripolis* of the Isle of France.

According to the chemical analysis of Bucholz, tripoli consists of—silica, 81; alumina 1.5; oxide of iron, 8; sulphuric acid, 3.45; water, 4.55. This specimen was probably found in a coal-field. The tripoli of Corfu is reckoned the best for scouring or brightening brass and other metals. Mr. Phillips found in the Derbyshire rotten-stone (near Bakewell), 86 of alumina, 4 of silica, and 10 of carbon—being a remarkable difference in composition from the Bohemian.

TUBES OF BRASS. Brass or other tubes are formed of rolled metal, which is cut to the required breadth by means of revolving discs: in the large sizes of tubes, the metal is partially curved in its length by means of a pair of rolls; when in this condition it is passed through a steel hole or a die, a plug being held in such a position as allows the metal to pass between it and the interior of the hole. Oil is used to lubricate the metal; the motion is communicated by power, the drawing apparatus being a pair of huge nippers, which holds the brass, and is attached to a chain and revolves round a windlass or cylinder. The tube in its unsoldered state is annealed, bound round at intervals of a few inches with iron wire, and solder and borax applied along the seam. The operation of soldering is completed by passing the tube through an air stove, heated with "cokes" or "breezes," which melts the solder, and unites the two edges of the metal, and forms a perfect tube; it is then immersed in a solution of sulphuric acid, to remove scaly deposits on its surface, the wire and extra solder having been previously removed: it is then drawn through a "finishing hole plate," when the tube is completed.

Mandril drawn tubes, as the name indicates, are drawn upon a very accurately turned steel mandril; by this means the internal diameter is rendered smooth; the tube formed by this process is well fitted for telescopes, syringes, small pump-cylinders, &c.

Brass solder is composed of almost equal quantities of copper and zinc; its properties should be that of melting at such a temperature as will allow the article to be soldered to be sufficiently heated, but yet some degrees from the melting point. Solder is always used in connection with borax, the cleansing properties of which appear to facilitate the fusion of the metal.

TUBULAR CRANE. Under the title **CRANE**, that elegant mechanical invention of William Fairbairn, Esq. F. R. S., Member of the French Institute, is described; and here an analysis of its structure by Sir D. Brewster may be inserted, as laid before the meeting of the British Association for 1851. These structures indicate some additional examples of the extension of the tubular system, and the many advantages that may yet be derived from a judicious combination of wrought iron plates, and a careful distribution of the material in all those combinations which require security, rigidity, and strength.

The projection or radius of the jib of these cranes is 32 feet 6 inches from the centre of the stem, and its height 30 feet above the ground. It is entirely composed of wrought iron plates, firmly rivetted together on the principle of the upper side being calculated to resist tension, and the under, or concave side, which embodies the cellular construction, to resist compression. The form is correctly that of the prolonged vertebrae of the bird from which this machine for raising weights takes its name; it is truly the neck of the crane, tapering from the point of the jib, where it is 2 ft. deep by 18 inches wide, to the level of the ground, where it is 5 ft. deep and 3 ft. 6 inches wide. From this point it again tapers to a depth of 18 ft. under the surface, where it terminates in a cast-iron shoe, which forms the toe on which it revolves. The lower or concave side, which is calculated to resist compression, consists of plates forming three cells, and varying in thickness in the ratio of the strain; as also the convex top, which is formed of long plates chain rivetted with covers; but the sides are of uniform thickness, rivetted with T iron, and covering plates $4\frac{1}{2}$ inches wide over each joint. This arrangement of the parts and distribution of the materials constitute the principal elements of strength in the crane. The form of the jib, and the point at which the load is suspended, is probably not the most favourable for resisting pressure. It nevertheless exhibits great powers of resistance; and its form, as well as the position, may safely be considered as a curved hollow beam having one end immovably fixed at *a*, and the other end *c*, the part to which the force is applied. Viewing it in this light, the strengths are easily determined; and taking the experiments herein recorded, we have by the formula*, which was originally framed for the calculation of the ultimate strength of tubular beams, that a load of 63 tons would be required to break the crane. With 20 tons the deflection was 3.97—64 of a permanent set = 3.33 inches, the deflection of the jib due to a load of 20 tons. The following constitute the experiments made at Keyham docks.

* $W = \frac{adC}{l}$, where *W* = breaking weight in tons; *a* the sectional area of the bottom of beam subject to tension; *d* the depth of beam; *C* (80), a constant derived from experiment, and *l* the length of beam—all in inches.

Experiments made to ascertain the resisting Powers of a new wrought-iron tubular Crane erected at Keyham Dockyard, Devonport, November 8. 1850.

| Weight of cargo in tons. | Deflection at the point of the jib in inches. |
|-----------------------------|--|
| 2 | .32 |
| 3 | .50 |
| 4 | .65 |
| 5 | .90 |
| 6 | 1.05 |
| 7 | 1.20 |
| 8 | 1.35 |
| 9 | 1.50 |
| 10 | 1.70 |

With 5 tons suspended, the crane was turned completely round, without any alteration in the deflection.

With this weight the crane was again turned round; the deflection in 8 minutes increasing to 1.85 inches, when it became permanent, after sustaining the load during the whole of the night, a period of about 16 hours.

On 9th November the experiments were resumed as follows :

| Weight of cargo in tons. | Deflection at the point of the jib in inches. |
|-----------------------------|--|
| 11 | 2.05 |
| 12 | 2.22 |
| 13 | 2.40 |
| 14 | 2.60 |
| 15 | 2.80 |
| 16 | 3.00 |
| 17 | 3.20 |
| 18 | 3.50 |
| 19 | 3.73 |
| 20 | 3.97 |

On again turning the crane round with a load of 20 tons there was no perceptible alteration in the deflection, and the permanent set, after removing the load, was .64 inches.

From the above experiments, it appears that the ultimate strength of the crane is much greater than is requisite either in theory or practice, and, although tested with nearly a double load, it is still far short of its ultimate powers of resistance, which it will be observed are five times greater than the weight it is intended to bear.

The advantages claimed for this construction are its great security, and the facility with which bulky and heavy bodies can be raised to the very top of the jib without failure. It moreover exhibits, when heavily loaded, the same restorative principle of elasticity strikingly exemplified in the wrought-iron tubular girder. These constructions, although different in form, are nevertheless the same in principle, and undoubtedly follow the same law as regards elasticity and their powers of resistance to fracture. They all do great honour to the mechanical genius of Mr. Fairbairn.

TUFA, or TUF, is a gray deposit of calcareous carbonate from springs and streams.

TULA METAL, is an alloy of silver, copper, and lead; made at Tula in Russia.

TUNGSTEN (Eng. and Fr.; *Wolfram*, Germ.); is a peculiar metal, which occurs in the state of an acid (the *tungstic*), combined with various bases, as with lime, the oxides of iron, manganese, and lead. The metal is obtained by reduction of the ore, or the deoxidisation of the acid, in the form of a dark steel-gray powder, which assumes under the burnisher a feeble metallic lustre. Its specific gravity is 17.22.

TURBITH MINERAL, is the yellow subsulphate of mercury.

TURF (*Peat*, Scotch; *Tourbe*, Fr.; *Turf*, Germ.); consists of vegetable matter, chiefly of the moss family, in a state of partial decomposition by the action of water; Cut, during summer, into brick-shaped pieces, and dried, it is extensively used as fuel by the peasantry in every region where it abounds. The dense black turf, which forms the lower stratum of a peat moss, is much contaminated with iron, sulphur, sand, &c., while the lighter turf of the upper strata, though nearly pure vegetable matter, is too bulky for transportation, and too porous for factory fuel. These defects have been happily removed by Mr. Williams, managing director of the Dublin Steam Navigation Company, who has obtained a patent for a method of converting the lightest

and purest beds of peat-moss, or bog, into the four following products: 1. A brown combustible solid, denser than oak; 2. A charcoal, twice as compact as that of hard wood; 3. A factitious coal; and 4. A factitious coke; each of which possesses very valuable properties.

Mr. D'Ernst, artificer of fire-works to Vauxhall, has proved, by the severe test of coloured fires, that the turf charcoal of Mr. Williams is 20 per cent. more combustible than that of oak. Mr. Oldham, engineer of the Bank of England, applied it in softening his steel plates and dies, with remarkable success. But one of the most important results of Mr. Williams's invention is, that with 10 cwts. of pitcoal and $2\frac{1}{2}$ cwts. of his factitious coal, the same steam power is now obtained, in navigating the Company's ships, as with $17\frac{1}{2}$ cwts. of pitcoal alone; thereby saving 30 per cent. in the stowage of fuel. What a prospect is thus opened up of turning to admirable account the unprofitable bogs of Ireland; and of producing, from their inexhaustible stores, a superior fuel for every purpose of arts and engineering.

The turf is treated as follows: — Immediately after being dug, it is triturated under revolving edge-wheels, faced with iron plates perforated all over their surface, and is forced by the pressure through these apertures, till it becomes a species of pap, which is freed from the greater part of its moisture by squeezing in a hydraulic press between layers of caya cloth, then dried, and cooked in suitable ovens. — (See CHARCOAL, and PITCOAL, COKING OF.) Mr. Williams makes his factitious coal by incorporating with pitch or rosin, melted in a cauldron, as much of the above charcoal, ground to powder, as will form a doughy mass, which is moulded into bricks in its hot and plastic state. From the experiments of M. Le Sage, detailed in the 5th volume of "The Repertory of Arts," charred ordinary turf seems to be capable of producing a far more intense heat than common charcoal. It has been found preferable to all other fuel for case-hardening iron, tempering steel, forging horse-shoes, and welding gun-barrels. Since turf is partially carbonized in its native state, when it is condensed by the hydraulic press, and fully charred, it must evidently afford a charcoal very superior in calorific power to the porous substance generated from wood by fire.

TURKEY RED, is a brilliant dye produced on cotton goods by MADDER.

TURMERIC, (*Curcuma*, *Terra merita*, (*Souchet* or *Safran des Indes*, Fr.; *Gelbwurzel*, Germ.); is the root of the *Curcuma longa* and *rotunda*, a plant which grows in the East Indies, where it is much employed in dyeing yellow, as also as a condiment in curry sauce or powder. The root is knotty, tubercular, oblong, and wrinkled; pale-yellow without, and brown-yellow within; of a peculiar smell, a taste bitterish and somewhat spicy. It contains a peculiar yellow principle, called *curcumine*, a brown colouring-matter, a volatile oil, starch, &c. The yellow tint of turmeric is changed to brown-red by alkalis, alkaline earths, subacetate of lead, and several metallic oxides; for which reason, paper stained with it is employed as a chemical test.

Turmeric is employed by the wool-dyers for compound colours which require an admixture of yellow, as for cheap browns and olives. As a yellow dye, it is employed only upon silk. It is a very fugitive colour. A yellow lake may be made by boiling turmeric powder with a solution of alum, and pouring the filtered decoction upon pounded chalk.

TURNSOLE. See ARCHIL and LITHUM.

TURPENTINE (*Terebinthina*, Fr.; *Turpentin*, Germ.); is a substance which flows out of incisions made in the stems of several species of pines. It has the consistence and gray-yellow colour of honey. It has a smell which is not disagreeable to many persons, a warm, sharp, bitterish taste; dries into a solid in the air, with the evaporation of its volatile oil. It becomes quite fluid at a moderate elevation of temperature, and burns at a higher heat, with a bright but very fuliginous flame. There are several varieties of turpentine.

1. *Common turpentine*, is extracted from incisions in the *Pinus abies* and *Pinus sylvestris*. It has little smell; but a bitter burning taste. It consists of the volatile oil of turpentine to the amount of from 5 to 25 per cent.; and of rosin or colophony.

2. *Venice turpentine*, is extracted from the *Pinus larix* (larch), and the French turpentine from the *Pinus maritima*. The first comes from Styria, Hungary, the Tyrol, and Switzerland, and contains from 18 to 25 per cent. of oil; the second, from the south of France, and contains no more than 12 per cent. of oil. The oil of all the turpentines is extracted by distilling them along with water. They dissolve in all proportions in alcohol, without leaving any residuum. They also combine with alkaline lyes, and in general with the salifiable bases. Venice turpentine contains also succinic acid.

3. Turpentine of Strasbourg is extracted from the *Pinus picea* and *Abies excelsa*. It affords 33.5 per cent. of volatile oil, and some volatile or crystallisable resin, with extractive matter and succinic acid.

4. Turpentine of the Carpathian mountains, and of Hungary; the first of which

comes from the *Pinus cembra*, and the second from the *Pinus mugé*. They resemble that of Strasbourg.

5. Turpentine of Canada, called Canada balsam, is extracted from the *Pinus canadensis* and *balsamea*. Its smell is much more agreeable than that of the preceding species.

6. Turpentine of Cyprus or Chio is extracted from the *Pinus terabinthus*. It has a yellow, greenish, or blue-green colour. Its smell is more agreeable, and taste less acrid, than those of the preceding sorts.

TURPENTINE, OIL OF, sometimes called essence of turpentine. As found in commerce, it contains more or less rosin, from which it may be freed by re-distillation along with water. It is colourless, limpid, very fluid, and possessed of a very peculiar smell. Its specific gravity, when pure, is 0.870; that of the oil commonly sold in London is 0.875. It always reddens litmus paper, from containing a little succinic acid. According to Oppermann, the oil which has been repeatedly rectified over chloride of calcium, consists of 84.60 carbon, 11.735 hydrogen, and 3.67 oxygen. When oil of turpentine contains a little alcohol, it burns with a clear flame; but otherwise it affords a very smoky flame. Chlorine inflames this oil; and muriatic acid converts it into a crystalline substance, like camphor. It is employed extensively in varnishes, paints, &c., as also in medicine.

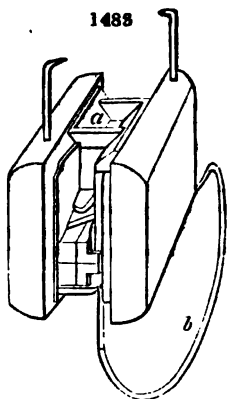
TURPENTINE, SPIRITS, ESSENCE, OR OIL OF. Camphen is the new name given by the continental chemists to every ethereous or volatile oil which is composed of 5 atoms of carbon and 8 of hydrogen, and which combines directly with hydrochloric acid, either into a solid or a liquid compound, resembling camphor. Under this title the following oils are included:—turpentine, citron, or lemon, orange-flower, copaiva, balsam oil, juniper, cubebs, and pepper. Some add to this last,—the oils of cloves, valerian, and bergamot. As the new patent lamps burn spirits of turpentine, they have been called Camphine. See LAMPS.

Common turpentine imported into the United Kingdom, in 1850, 487,121 cwts.; in 1851, 491,950 cwts.

TURQUOIS. See LAPIDARY.

TUTENAG, is an alloy of copper and zinc.

TYPE, (*Caractère*, Fr; *Druckbuchstabe*, Germ.) The first care of the letter-cutter is to prepare well tempered steel punches, upon which he draws or marks the exact shape of the letter, with pen and ink if it be large, but with a smooth blunted point of a needle if it be small; and then, with a proper sized and shaped graver and sculpter, he digs or scoops out the metal between the strokes upon the face of the punch, leaving the marks untouched and prominent. He next works the outside with files till it be fit for the matrix. Punches are also made by hammering down the hollows, filing up the edges, and then hardening the soft steel. Before he proceeds to sink and justify the matrix, he provides a mould to justify them by, of which a good figure is shown in plate xv., *Miscellany*, figs. 2. 3. of *Rees's Cyclopaedia*.



A matrix is a piece of brass or copper, about an inch and a half long, and thick in proportion to the size of the letter which it is to contain. In this metal the face of the letter intended to be cast is sunk, by striking it with the punch to a depth of about one eighth of an inch. The mould, *fig.* 1483., in which the types are cast, is composed of two parts. The outer part is made of wood, the inner of steel. At the top it has a hopper-mouth *a*, into which the fused type-metal is poured. The interior cavity is as uniform as if it had been hollowed out of a single piece of steel; because each half, which forms two of the four sides of the letter, is exactly fitted to the other. The matrix is placed at the bottom of the mould, directly under the centre of the orifice, and is held in its position by a spring *b*. Every letter that is cast can be loosened from the matrix only by removing the pressure on the spring.

A good type-foundry is always provided with several furnaces, each surmounted with an iron pot containing the melted alloy, of 3 parts of lead and 1 of antimony. Into this pot the founder dips the very small iron ladle, to lift merely as much metal as will cast a single letter at a time. Having poured in the metal with his right hand, and returned the ladle to the melting-pot, the founder throws up his left hand, which holds the mould, above his head, with a sudden jerk, supporting it with his right hand. It is this movement which forces the metal into all the interstices of the matrix: for without it, the metal, especially in the smaller moulds, would not be able

to expel the air and reach the bottom. The pouring in the metal, the throwing up the mould, the unclosing it, removing the pressure of the spring, picking out the cast letter, closing the mould again, and re-applying the spring to be ready for a new operation, are all performed with such astonishing rapidity and precision, that a skilful workman will turn out 500 good letters in an hour, being at the rate of one every eighth part of a minute. A considerable piece of metal remains attached to the end of the type as it quits the mould. There are nicks upon the lower edge of the types, to enable the compositor to place them upright, without looking at them.

From the table of the *caster*, the heap of types turned out of his mould, is transferred from time to time to another table, by a boy, whose business it is to break off the superfluous metal, and that he does so rapidly as to clear from 9000 to 5000 types in an hour; a very remarkable dispatch, since he must seize them by their edges, and not by their feeble flat sides. From the breaking-off boy, the types are taken to the *rubber*, a man who sits in the centre of the workshop with a grit-stone alab on a table before him, and having on the fore and middle finger of his right hand a piece of tarred leather, passes each broad side of the type smartly over the stone, turning it in the movement, and that so dexterously as to be able to rub 9000 types in an hour.

From the rubber, the types are conveyed to a boy, who with equal rapidity sets them up in lines, in a long shallow frame, with their faces uppermost and nicks outwards. This frame containing a full line is put into the dresser's hands, who polishes them on each side, and turning them with their faces downwards, cuts a groove or channel in their bottom, to make them stand steadily on end. It is essential that each letter be perfectly symmetrical and square; the least inequality of their length would prevent them from making a fair impression; and were there the least obliquity in their sides, it would be quite impossible, when 200,000 single letters are combined, as in one side of the *Times* newspaper, that they could hold together as they require to do, when wedged up in the chases, as securely as if that side of the type formed a solid plate of metal. Each letter is finally tied up in lines of convenient length, the proportionate numbers of each variety, small letters, points, large capitals, small capitals, and figures, being selected, when the fount of type is ready for delivery to the printer.

The sizes of types cast in this country vary, from the smallest, called diamond, of which 205 lines are contained in a foot length, to those letters employed in placards, of which a single letter may be 3 or 4 inches high. The names of the different letters and their dimensions, or the number of lines which each occupies in a foot, are stated in the following table:—

| | | | | | |
|----------------|-------|---------------|--------|-------------|-------|
| Double Pica - | - 41½ | Small Pica - | - 83 | Minion - | - 128 |
| Paragon - | - 44½ | Long Primer - | - 89 | Nonpareil - | - 143 |
| Great Primer - | - 51½ | Bourgeois - | - 102½ | Pearl - | - 178 |
| English - | - 64 | Brevier - | - 112½ | Diamond - | - 205 |
| Pica - | - 71½ | | | | |

T. Aspinwall, Esq., American consul, obtained, in May, 1828, a patent for an improved method of casting printing types by means of a mechanical process, being a communication from a foreigner residing abroad. The machine is described, with six explanatory figures, in the Second Series of *Newton's Journal*, vol. v. page 212. The patentee does not claim, as his invention, any of the parts separately, but the general process and arrangement of machinery; more particularly the manner of suspending a swing table (upon which the working parts are mounted) out of the horizontal and perpendicular position; the mode of moving the table with the parts of the mould towards the melting-pot; the manner of bringing the parts of the mould together, and keeping them closed during the operation of casting the types. Several other mechanical schemes have been proposed for founding types, but I have been informed by very competent judges, Messrs. Clowes, that none of them can compete in practical utility with that dexterity and precision of handiwork, which I have often seen practised in their great printing establishment in Stamford-street.

U.

ULTRAMARINE (*Outremer*, Fr.; *Ultramarine*, Germ.); is a beautiful blue pigment obtained from the variegated blue mineral, called lazulite (*lapis lazuli*), by the following process:— Grind the stone to fragments, rejecting all the colourless bits, calcine at a red heat, quench in water, and then grind to an impalpable powder along with water, in a paint-mill, (see PAINTS, GRINDING OR,) or with a porphyry slab and muller. The paste being dried, is to be rubbed to powder, and passed through a silk sieve. 100 parts of it are to be mixed with 40 of rosin, 20 of white wax, 25 of linseed oil, and 15 of Burgundy pitch, previously melted together. This resinous compound is to be poured hot into cold water; kneaded well first with two spatulas, then with the hands, and then formed into one or more small rolls. Some persons prescribe leaving these pieces in the water during 15 days, and then kneading them in it, whereby they give out the blue pigment, apparently because the ultramarine matter adheres less strongly than the *gangue*, or merely siliceous matter of the mineral, to the resinous paste. M. M. Clement and Desormes, who were the first to divine the true nature of this pigment, think that the soda contained in the lazulite, uniting with the oil and the rosin, forms a species of soap, which serves to wash out the colouring matter. If it should not separate readily, water heated to about 150° F. should be had recourse to. When the water is sufficiently charged with blue colour, it is poured off and replaced by fresh water; and the kneading and change of water are repeated till the whole of the colour is extracted. Others knead the mixed resinous mass under a slender stream of water, which runs off with the colour into a large earthen pan. The first waters afford, by rest, a deposit of the finest ultramarine; the second, a somewhat inferior article, and so on. Each must be washed afterwards with several more waters, before they acquire the highest quality of tone; then dried separately, and freed from any adhering particles of the pitchy compound by digestion in alcohol. The remainder of the mass being melted with oil, and kneaded in water containing a little soda or potash, yields an inferior pigment, called *ultramarine ashes*. The best *ultramarine* is a splendid blue pigment, which works well with oil, and is not liable to change by time. Its price in Italy was five guineas the ounce, a few years ago, but it is now greatly reduced.

The blue colour of *lazulite* had been always ascribed to iron, till M. M. Clement and Desormes, by a most careful analysis, showed it to consist of—silica, 34; alumina, 33; sulphur, 3; soda, 22; and that the iron, carbonate of lime, &c. were accidental ingredients, essential neither to the mineral, nor to the pigment made from it. By another analyst, the constituents are said to be—silica, 44; alumina, 35; and soda, 21; and by a third, potassa was found instead of soda, showing shades of difference in the composition of the stone.

Till a few years ago, every attempt failed to make ultramarine artificially. At length, in 1828, M. Guimet resolved the problem, guided by the analysis of M. M. Clement and Desormes, and by an observation of M. Tassaert, that a blue substance like ultramarine was occasionally produced on the sandstone hearths of his reverberatory soda furnaces. Of M. Guimet's finest pigment I received a bottle several years ago, from my friend M. Merimée, secretary of the *École de Beaux Arts*, which has been found by artists little, if any, inferior to the lazulite ultramarine. M. Guimet sold it at 60 francs per pound French, — which is a little more than two guineas the English pound. He has kept his process secret. But M. Gmelin, of Tübingen, has published a prescription for making it; which consists in enclosing carefully in a Hessian crucible a mixture of 2 parts of sulphur, and 1 of dry carbonate of soda, heating them gradually to redness until the mass fuses, and then sprinkling into it by degrees another mixture, of silicate of soda, and aluminate of soda; the first containing 72 parts of silica, and the second 70 parts of alumina. The crucible must be exposed after this for an hour to the fire. The ultramarine will be formed by this time; only it contains a little sulphur, which can be separated by means of water. M. Persoz, professor of chemistry at Strasbourg, has likewise succeeded in making an ultramarine, of perhaps still better quality than that of M. Guimet. Lastly, M. Robiquet has announced, that it is easy to form ultramarine by heating to redness a proper mixture of kaolin (Chiffon clay), sulphur, and carbonate of soda. It would therefore appear, from the preceding details, that ultramarine may be regarded as a compound of silicate of alumina, silicate of soda, with sulphure of sodium: and that to the reaction of the last constituent upon the former two, it owes its colour.

ANALYSIS OF ULTRAMARINE BY WARRENTRAP.

| Lapis Lazuli. | Artificial from Meissen. | Blue. | Elsner. | Green. |
|----------------|--------------------------|-------|---------|--------|
| Potash | 1.75 | | | |
| Soda | 21.47 | 40.0 | | 25.5 |
| Alumina | 31.07 | 29.30 | 29.5 | 30.0 |
| Silica | 42.50 | 45.00 | 40.0 | 39.9 |
| Sulphur | 0.95 | 1.68 | 4.0 | 4.6 |
| Lime | 8.52 | 0.09 | | |
| Iron | 0.86 | 1.06 | 1.0 | 0.9 |
| Chlorine | 0.42 | | | |
| Sulphuric Acid | 5.89 | 2.88 | 2.4 | 0.4 |
| Water | 0.12 | | | |

ULTRAMARINE, ARTIFICIAL. Till within these last 16 or 18 years, the only source of this beautiful pigment was the rare mineral *lapis lazuli*. The price of the finest ultramarine was then so high as five guineas the ounce. Since the mode of making it artificially has been discovered, however, its price has fallen to a few shillings per pound, and even to a little more than one shilling wholesale, for a fair article. Artificial ultramarine is now manufactured to a very considerable extent on the Continent, and also in London. The chief French manufactories of ultramarine are situated in Paris, and the two largest ones in Germany are those of Meissen in Saxony, and of Nuremberg in Franconia. Three kinds of ultramarine occur in commerce, the blue, the green, and the yellow. The two first only are true ultramarines; that is, sulphur compounds; the yellow is merely chromate of baryta.

Both native and artificial ultramarine have been examined very carefully by several eminent chemists, who, however, have been unable to throw much light upon their true nature. Chemists have undoubtedly ascertained that ultramarine always consists of silica, alumina, soda, sulphur, and a little oxide of iron; but no two specimens, either of the native or artificial ultramarine, contain these ingredients in at all similar proportions. In fact the discrepancies between the analyses are so great, as to render it impossible to deduce from them any formula for the constitution of ultramarine; if indeed it does possess any definite composition. The following are a few specimens of these analyses, and others equally discordant might easily be added.

| | Lapis Lazuli, by Clement and Desormes. |
|-------------------|--|
| Soda | 23.2 |
| Alumina | 24.8 |
| Silica | 33.9 |
| Sulphur | 3.1 |
| Carbonate of lime | 3.1 |

| | Parisian artificial ultramarine, by C. G. Gmelin. |
|--------------------------|---|
| Soda and potash | 12.863 |
| Lime | 1.546 |
| Alumina | 22.000 |
| Silica | 47.906 |
| Sulphuric acid | 4.679 |
| Resin, sulphur, and loss | 12.218 |

Dr. Elsner published a very elaborate paper upon ultramarine in the 26th number of *Erdmann's Journal* for 1841. The first part of Dr. Elsner's paper is historical, and contains an account of the accidental discovery of artificial ultramarine by Tassaert and Kuhlman in 1814, and of the labours of subsequent chemists. He then gives a detailed account of his own experiments, which have been very numerous, and from these he deduces the following conclusions: 1st, that the presence of about 1 per cent. of iron is indispensable to the production of ultramarine; he supposes the iron to be in a state of sulphuret. 2d, that the green ultramarine is first formed, and that as the heat is increased, it passes by degrees into the blue. The cause of this change is, he affirms, that part of the sodium absorbs oxygen from the atmosphere, as the operation is conducted in only partially closed vessels, and combines with the silica, while the rest of the sodium passes into a higher degree of sulphuration. Green ultramarine, therefore, contains simple sulphurets, and blue, polysulphurets.

Dr. Elsner's paper does not, however, furnish any details by which ultramarine could be manufactured successfully on the great scale. Thus, for example, in regard to the

necessary degree of heat, perhaps the most important circumstance in the process, he gives no directions whatever. We know however, from other sources, that it should be a low red heat, as at much higher temperatures both native and artificial ultramarines soon become colourless. Dr. Elmer, indeed, does not affirm that he was able to procure ultramarine in quantity of a uniformly good colour. In fact, the process of Robiquet, published nearly ten years ago, is the best which scientific chemists possess, though undoubtedly the manufacturers have greatly improved upon it. Robiquet's process consists in heating to low redness a mixture of one part porcelain clay, one and a half sulphur, and one and a half parts anhydrous carbonate of soda, either in an earthenware retort or covered crucible, so long as vapours are given off. When opened, the crucible usually contains a spongy mass of a deep blue colour, containing more or less ultramarine mixed with the excess of sulphur employed, and some unaltered clay and soda. The soluble matter is removed by washing, and the ultramarine separated from the other impurities by levigation. It is to be regretted, however, that the results of Robiquet's process are by no means uniform; one time it yields a good deal of ultramarine of excellent quality, and perhaps, at the very next repetition of the process in circumstances apparently similar, very little ultramarine is obtained, and that of an inferior quality.

The fabrication of ultramarine is a subject which well deserves the attention of English chemical manufacturers, as it could be carried on with peculiar advantage in this country. The chief expense of the process is the fuel required, which can be purchased in Great Britain for less than half the money it would cost either in France or Germany.

UMBER, is a massive mineral; fracture large and flat; conchoidal in the great, very fine earthy in the small; dull; colour, liver, chestnut, — dark yellowish brown; opaque; does not soil, but writes; adheres strongly to the tongue, feels a little rough and meagre, and is very soft; specific gravity 2.2. It occurs in beds with brown jasper in the island of Cyprus, and is used by painters as a brown colour, and to make varnish dry quickly.

URANIUM, is a rare metal, first discovered by Klaproth, in the black mineral called *pechblende*, found in a mine near Johann-Georgen-Stadt, in Saxony, and which is a sulphuret of uranium. A double phosphate of uranium and copper, called *green uranite*, and *uran mica*, occurs in Cornwall. It has been reduced to the metallic state by various devices, but it has hardly the appearance of metal to the naked eye, and from the rarity of its ores is not likely to be of any importance in the arts, except to colour glass.

URAO, is the native name of a sesquicarbonate of soda found at the bottom of certain lakes in Mexico, especially to the north of Zacatecas, and in several other provinces; also in South America at Columbia, 48 English miles from Merida.

UREA. The quantity of urea present in urine may be estimated with great facility by treating the urine with a standard solution of the pernitrate of mercury. A copious white precipitate, resembling the chloride of silver, with liberation of nitric acid, falls. As this acid prevents the further action of the nitrate, it must be neutralized by water of barytes. A further quantity of the nitrate of mercury is to be now added, and so on, by repeated additions of the test, and subsequent neutralization with barytes, till the whole urea is precipitated. The addition of more of the nitrate of mercury produces a yellow precipitate of binoxide of mercury. The quantity of urea present in a given sample of urine, may thus be readily deduced from the quantity of a solution of nitrate of mercury required for its precipitation. The urine should be fresh.

V.

VACUUM-MADE LIQUEURS. Samples of brandy made of alcohol and fruits of various kinds by distillation in a vacuum.

In this manufacture about 300 lbs. of these fruits yield nearly 7 quarts of black cherry brandy, having the flavour of prussic ether.

These brandies may serve as the basis of all compositions of fruit tafias, without prejudice to the delicacy of the flavour. The brandy has the taste and flavour of the fruit. It is mild and destitute of the burning taste common to wine brandy. Pure or mixed with water it is an agreeable drink, and may from its variety, taste, and flavour, advantageously replace other spirituous mixtures.

The liqueurs prepared from these various sorts of brandy are called *marasquin*, on account of their analogy to those of Venice and Trieste. They are manufactured from the fruit of a variety of laurels (cherry bay), called in Italy *marasca*.

The distillation *in vacuo* deprives the mixture of the coarse essential oil which remains after ordinary distillation, and which contains the resinous and heterogeneous substances so disagreeable to the palate and injurious to the stomach. The distillation *in vacuo* is carried on at from 40° to 50° of temperature, instead of 120° to 150° in the ordinary process.

This *marasquin* from the wild or brandy cherry is a cephalic. The cherry is tonic and mild. The peach approximates to the cherry. The strawberry is diuretic and beneficial in phthisical complaints and weak constitutions. The raspberry is cooling and antiscorbutic; mixed with water it is a sweet and agreeable beverage. The flavour of the black currant is very superior, and the operation of the vacuum, instead of weakening, concentrates the properties of the fruit. *An Exhibition puff.*

VALONIA, is a kind of acorn, imported from the Levant and the Morea for the use of tanners, as the husk or cup contains abundance of tannin. The quantity imported for home consumption in 1850, was 12,526 tons; in 1851, 10,639 tons.

VANADIUM, is a metal discovered by Sefström, in 1830, in a Swedish iron, remarkable for its ductility, extracted from the iron mine of Jäberg, not far from Jonköping. Its name is derived from Vanadis, a Scandinavian idol. This metal has been found in the state of vanadic acid in a lead ore from Zimapan, in Mexico. The finery *cinder* of the Jäberg iron contains more vanadium than the metal itself. It exists in it as vanadic acid. For the reduction of this acid to vanadium, see Berzelius's *Traité de Chimie*, vol. iv. p. 644. Vanadium is white, and when its surface is polished, it resembles silver or molybdenum more than any other metal. It combines with oxygen into two oxides and an acid.

The vanadate of ammonia, mixed with infusion of nutgalls, forms a black liquid, which is the best writing-ink hitherto known. The quantity of the salt requisite is so small as to be of no importance when the vanadium comes to be more extensively extracted. The writing is perfectly black. The acids colour it blue, but do not remove it, as they do tannate of iron: the alkalis, diluted so far as not to injure the paper, do not dissolve it; and chlorine, which destroys the black colour, does not, however, make the traces illegible, even when they are subsequently washed with a stream of water. It is perfectly fluent, and, being a chemical solution, stands in want of no viscid gum to suspend the colour, like common ink. The influence of time upon it remains to be tried.

VANILLA, is the oblong narrow pod of the *Epidendron vanilla*, Linn., of the natural family *Orchideæ*, which grows in Mexico, Columbia, Peru, and on the banks of the Orinoco.

The best comes from the forests round the village of Zentila, in the intendancy of Oaxaca.

The vanilla plant is cultivated in Brazil, in the West Indies, and some other tropical countries, but does not produce fruit of such a delicious aroma as in Mexico. It clings like a parasite to the trunks of old trees, and sucks the moisture which their bark derives from the lichens, and other cryptogamia, but without drawing nourishment from the tree itself, like the ivy and mistletoe. The fruit is subcylindric, about 8 inches long, one-celled, siliquose, and pulpy within. It should be gathered before it is fully ripe.

When about 12,000 of these pods are collected, they are strung like a garland by their lower end, as near as possible to the foot-stalk; the whole are plunged for an instant in boiling water to blanch them; they are then hung up in the open air, and exposed to the sun for a few hours. Next day they are lightly smeared with oil, by means of a feather, or the fingers; and are surrounded with oiled cotton, to prevent the valves from opening. As they become dry, on inverting their upper end, they discharge a viscid liquid from it, and they are pressed at several times with oiled fingers, to promote its flow. The dried pods lose their appearance, grow brown, wrinkled, soft, and shrink into one-fourth of their original size. In this state they are touched a second time with oil, but very sparingly; because, with too much oil, they would lose much of their delicious perfume. They are then packed for the market, in small bundles of 50 or 100 in each, enclosed in lead foil, or tight metallic cases. As it comes to us, vanilla is a capsular fruit, of the thickness of a swan's quill, straight, cylindrical, but somewhat flattened, truncated at the top, thinned off at the ends, glistening, wrinkled, furrowed lengthwise, flexible, from 5 to 10 inches long, and of a reddish-brown colour. It contains a pulpy parenchyma, soft, unctuous, very brown, in which are imbedded black, brilliant, very small seeds. Its smell is ambrosiacal and aromatic; its taste hot, and

rather sweetish. These properties seem to depend upon an essential oil, and also upon benzoic acid, which forms efflorescences upon the surface of the fruit. The pulpy part possesses alone the aromatic quality; the pericarpium has hardly any smell.

The kind most esteemed in France, is called *leg vanilla*; it is about 6 inches long, from $\frac{1}{4}$ to $\frac{1}{2}$ of an inch broad, narrowed at the two ends, and curved at the base; somewhat soft and viscid, of a dark-reddish colour, and of a most delicious flavour, like that of balsam of Peru. It is called *vanilla giroées*, when it is covered with efflorescences of benzoic acid, after having been kept in a dry place, and in vessels not hermetically closed.

The second sort, called *vanilla simarona*, or bastard, is a little smaller than the preceding, of a less deep brown hue, drier, less aromatic, destitute of efflorescence. It is said to be the produce of the wild plant, and is brought from St. Domingo.

A third sort, which comes from Brazil, is the *vanillon*, or large vanilla of the French market; the *vanilla pamprona* or *bova* of the Spaniards. Its length is from 5 to 6 inches; its breadth from one-half to three-quarters of an inch. It is brown, soft, viscid, almost always open, of a strong smell, but less agreeable than the *leg*. It is sometimes a little spoiled by an incipient fermentation. It is cured with sugar, and enclosed in tin-plate boxes, which contain from 20 to 60 pods.

Vanilla, as an aromatic, is much sought after by makers of chocolate, ices, and creams; by confectioners, perfumers, and liquorists, or distillers. It is difficultly reduced to fine particles; but it may be sufficiently attenuated by cutting it into small bits, and grinding these along with sugar. The odorous principle can, for some purposes, be extracted by alcohol. Their analysis by Bucholz is unsatisfactory, and refers obviously to the coarsest sort. Berzelius says that the efflorescences are not acid.

VAPOUR (*Vapeur*, Fr.; *Dampf*, Germ.); is the state of elastic or aeriform fluidity into which any substance, naturally solid or liquid at ordinary temperatures, may be converted by the agency of heat. See EVAPORATION.

VARNISH. (*Vernis*, Fr.; *Firniss*, Germ.); is a solution of resinous matter, which is spread over the surface of any body, in order to give it a shining, transparent, and hard coat, capable of resisting, in a greater or less degree, the influences of air and moisture. Such a coat consists of the resinous parts of the solution, which remain in a thin layer upon the surface, after the liquid solvent has either evaporated away, or has dried up. When large quantities of spirit varnish are to be made, a common still, mounted with its capital and worm, is the vessel employed for containing the materials, and it is placed in a steam or water bath. The capital should be provided with a stuffing-box, through which a stirring-rod may pass down to the bottom of the still, with a cross-piece at its lower end, and a handle or winch at its top. After heating the bath till the alcohol boils and begins to distil, the heat ought to be lowered, that the solution may continue to proceed in an equable manner, with as little evaporation of spirit as possible. The operation may be supposed to be complete when the rod can be easily turned round. The varnish must be passed through a silk sieve of proper fineness; then filtered through porous paper, or allowed to clear leisurely in stone jars. The alcohol which has come over should be added to the varnish, if the just proportions of the resins have been introduced at first. The following are reckoned good French recipes for varnishes:—

White spirit varnish.—Sandarach, 250 parts; mastic in tears, 64; elemi resin, 32; turpentine (Venice), 64; alcohol, of 85 per cent., 1000 parts by measure.

The turpentine is to be added after the resins are dissolved. This is a brilliant varnish, but not so hard as to bear polishing.

Varnish for the wood toys of Spa.—Tender copal, 75 parts; mastic, 12.5; Venice turpentine, 6.5; alcohol, of 95 per cent., 1000 parts by measure; water ounces, for example, if the other parts be taken in ounces.

The alcohol must be first made to act upon the copal, with the aid of a little oil of lavender or camphor, if thought fit; and the solution being passed through a linen cloth, the mastic must be introduced. After it is dissolved, the Venice turpentine, previously melted in a water-bath, should be added; the lower the temperature at which these operations are carried on, the more beautiful will the varnish be. This varnish ought to be very white, very drying, and capable of being smoothed with pumice-stone and polished.

Varnish for certain parts of carriages.—Sandarach, 190 parts; pale shellac, 95; rosin, 125; turpentine, 190; alcohol, at 85 per cent., 1000 parts by measure.

Varnish for cabinet-makers.—Pale shellac, 750 parts; mastic, 64; alcohol, of 90 per cent., 1000 parts by measure. The solution is made in the cold, with the aid of frequent stirring. It is always muddy, and is employed without being filtered.

With the same resins and proof spirit a varnish is made for the bookbinders to do over their morocco leather.

The varnish of Watin, for gilded articles.—Gum lac, in grain, 125 parts; gamboge, 125; dragon's blood, 125; annatto, 125; saffron, 32. Each resin must be dissolved in

1000 parts by measure, of alcohol of 90 per cent. ; two separate tinctures must be made with the dragon's blood and annotto, in 1000 parts of such alcohol ; and a proper proportion of each should be added to the varnish, according to the shade of golden colour wanted.

For fixing engravings or lithographs upon wood, a varnish called *verdant* is used in France, which differs from others chiefly in containing more Venice turpentine, to make it sticky ; it consists of—sandarach, 250 parts ; mastic in tears, 64 ; rosin, 125 ; Venice turpentine, 250 ; alcohol, 1000 parts by measure.

Copal varnish.—Hard copal, 300 parts ; drying linseed or nut oil, from 125 to 250 parts ; oil of turpentine, 500 ; these three substances are to be put into three separate vessels ; the copal is to be fused by a somewhat sudden application of heat ; the drying oil is to be heated to a temperature a little under ebullition, and it is to be added by small portions at a time to the melted copal. When this combination is made, and the heat a little abated, the essence of turpentine, likewise previously heated, is to be introduced by degrees : some of the volatile oil will be dissipated at first ; but more being added, the union will take place. Great care must be taken to prevent the turpentine vapour from catching fire, which might occasion serious accidents to the operator. When the varnish is made, and has cooled down to about the 130th degree of Fahr., it may be strained through a filter, to separate the impurities and undissolved copal.

Almost all varnish-makers think it indispensable to combine the drying oil with the copal, before adding the oil of turpentine ; but in this they are mistaken. Boiling oil of turpentine combines very readily with fused copal ; and, in some cases, it would probably be preferable to commence the operation with it, adding it in successive small quantities. Indeed, the whitest copal varnish can be made only in this way ; for if the drying oil have been heated to nearly its boiling point, it becomes coloured, and darkens the varnish.

This varnish improves in clearness by keeping. Its consistence may be varied by varying the proportions of the ingredients, within moderate limits. Good varnish, applied in summer, should become so dry in 24 hours that the dust will not stick to it, nor receive an impression from the fingers. To render it sufficiently dry and hard for polishing, it must be subjected for several days to the heat of a stove.

Milk of wax, is a valuable varnish, which may be prepared as follows :—Melt in a porcelain capsule a certain quantity of white wax, and add to it, while in fusion, an equal quantity of spirit of wine, of sp. gr. 0.830 ; stir the mixture, and pour it upon a large porphyry slab. The granular mass is to be converted into a paste by the muller, with the addition, from time to time, of a little alcohol ; and as soon as it appears to be smooth and homogeneous, water is to be introduced in small quantities successively, to the amount of four times the weight of the wax. This emulsion is to be then passed through canvas, in order to separate such particles as may be imperfectly incorporated.

The *milk of wax*, thus prepared, may be spread with a smooth brush upon the surface of a painting, allowed to dry, and then fused by passing a hot iron (salamander) over its surface. When cold, it is to be rubbed with a linen cloth to bring out the lustre. It is to the unchangeable quality of an encaustic of this nature, that the ancient paintings upon the walls of Herculaneum and Pompeii owe their freshness at the present day.

The most recent practical account of the manufacture of varnishes, is that communicated by Mr. J. Wilson Neil to the Society of Arts, and published in the 49th volume of their "Transactions."

The building or shed wherein varnish is made, ought to be quite detached from any buildings whatever, to avoid accidents by fire. For general purposes, a building about 18 feet by 16 is sufficiently large for manufacturing 4000 gallons and upwards annually, provided there are other convenient buildings for the purpose of holding the utensils, and warehousing the necessary stock.

Procure a copper pan, made like a common washing-copper, which will contain from fifty to eighty gallons, as occasion may require ; when wanted, set it upon the boiling furnace, and fill it up with linseed oil within five inches of the brim. Kindle a fire in the furnace underneath, and manage the fire so that the oil shall gradually, but slowly, increase in heat for the first two hours ; then increase the heat to a gentle simmer ; and if there is any scum on the surface, skim it off with a copper ladle, and put the skimming away. Let the oil boil gently for three hours longer ; then introduce, by a little at a time, one quarter of an ounce of the best calcined magnesia for every gallon of oil, occasionally stirring the oil from the bottom. When the magnesia is all in, let the oil boil rather smartly for one hour ; it will then be sufficient. Lay a cover over the oil, to keep out the dust while the fire is withdrawn and extinguished by water ; next uncover the oil, and leave it till next morning ; and then, while it is yet hot, ladle it into the carrying-jack, or let it out through the pipe and cock ; carry it away, and deposit it in either a tin or leaden cistern, for wooden vessels will not hold it ; let it remain to settle for at least three months. The magnesia will absorb all the acid and mucilage from the oil, and

fall to the bottom of the cistern, leaving the oil clear and transparent, and fit for use. Recollect, when the oil is taken out, not to disturb the bottoms, which are only fit for black paint.

GENERAL OBSERVATIONS AND PRECAUTIONS TO BE OBSERVED IN MAKING VARNISHES.

Set on the boiling-pot with 8 gallons of oil; kindle the fire; then lay the fire in the gum-furnace; have as many 8lb. bags of gum-copal all ready weighed up, as will be wanted; put one 8lb. into the pot, put fire to the furnace, set on the gum-pot; in three minutes (if the fire is brisk) the gum will begin to fuse and give out its gas, steam, and acid; stir and divide the gum, and attend to the rising of it, as before directed. 8lbs. of copal take in general from sixteen to twenty minutes in fusing, from the beginning till it gets clear like oil, but the time depends very much on the heat of the fire, and the attention of the operator. During the first twelve minutes, while the gum is fusing, the assistant must look to the oil, and bring it to a smart simmer; for it ought to be neither too hot, nor yet too cold, but in appearance beginning to boil, which he is strictly to observe, and, when ready, to call out, "Bear a hand!" Then immediately both lay hold of a handle of the boiling-pot, lift it right up, so as to clear the plate, carry it out and place it on the ash-bed, the maker instantly returning to the gum-pot, while the assistant puts three copper ladlefuls of oil into the copper pouring-jack, bringing it in and placing it on the iron plate at the back of the gum-pot to keep hot until wanted. When the maker finds the gum is nearly all completely fused, and that it will in a few minutes be ready for the oil, let him call out, "Ready oil!" The assistant is then to lift up the oil-jack with both hands, one under the bottom and the other on the handle, laying the spout over the edge of the pot, and wait until the maker calls out, "Oil!" The assistant is then to pour in the oil as before directed, and the boiling to be continued until the oil and gum become concentrated, and the mixture looks clear on the glass; the gum-pot is now to be set upon the brick-stand until the assistant puts three more ladlefuls of hot oil into the pouring-jack, and three more into a spare tin for the third run of gum. There will remain in the boiling-pot still $3\frac{1}{2}$ gallons of oil. Let the maker put his right hand down the handle of the gum-pot near to the side, with his left hand near the end of the handle, and with a firm grip lift the gum-pot, and deliberately lay the edge of the gum-pot over the edge of the boiling-pot until all its contents run into the boiling-pot. Let the gum-pot be held, with its bottom turned upwards, for a minute right over the boiling-pot. Observe, that whenever the maker is beginning to pour, the assistant stands ready with a thick piece of old carpet, without holes, and sufficiently large to cover the mouth of the boiling-pot should it catch fire during the pouring, which will sometimes happen if the gum-pot is very hot; should the gum-pot fire, it has only to be kept bottom upwards, and it will go out of itself; but if the boiling-pot should catch fire, during the pouring, let the assistant throw the piece of carpet quickly over the blazing pot, holding it down all round the edges; in a few minutes it will be smothered. The moment the maker has emptied the gum-pot, he throws into it half a gallon of turpentine, and with the *swish* immediately washes it from top to bottom, and instantly empties it into the flat tin jack: he wipes the pot dry, and puts in 8lbs. more gum, and sets it upon the furnace; proceeding with this run exactly as with the last, and afterwards with the third run. There will then be 8 gallons of oil and 24lbs. of gum in the boiling-pot, under which keep up a brisk strong fire until a scum or froth rises and covers all the surface of the contents, when it will begin to rise rapidly. Observe, when it rises near the rivets of the handles, carry it from the fire, and set it on the ash-bed, stir it down again, and scatter in the driers by a little at a time; keep stirring, and if the frothy head goes down, put it upon the furnace, and introduce *gradually* the remainder of the driers, always carrying out the pot when the froth rises near the rivets. In general, if the fire be good, all the time a pot requires to boil, from the time of the last gum being poured in, is about three and a half or four hours; but *time* is no criterion for a beginner to judge by, as it may vary according to the weather, the quality of the oil, the quality of the gum, the driers, or the heat of the fire, &c.; therefore, about the third hour of boiling, try it on a bit of glass, and keep it boiling until it feels strong and stringy between the fingers; it is then boiled sufficiently to carry it on the ash-bed, and to be stirred down until it is cold enough to mix, which will depend much on the weather, varying from half an hour, in dry frosty weather, to one hour in warm summer weather. Previous to beginning to mix, have a sufficient quantity of turpentine ready, fill the pot, and pour in, stirring all the time at the top or surface, as before directed, until there are fifteen gallons, or five tins of oil of turpentine introduced, which will leave it quite thick enough if the gum is good, and has been well run; but if the gum was of a weak quality, and has not been well fused, there ought to be no more than twelve gallons of turpentine mixed, and even that may be too much. Therefore, when twelve gallons of turpentine have been introduced, have a flat saucer at hand, and pour into it

a portion of the varnish, and in two or three minutes it will show whether it is too thick; if not sufficiently thin, add a little more turpentine, and strain it off quickly. As soon as the whole is stored away, pour in the turpentine washings, with which the gum-pots have been washed, into the boiling-pot, and with the swish quickly wash down all the varnish from the pot sides; afterwards, with a large piece of woollen rag dipped in pumice-powder, wash and polish every part of the inside of the boiling-pot, performing the same operation on the ladle and stirrers; rinse them with the turpentine washings, and at last rinse them altogether in clean turpentine, which also put to the washings; wipe dry with a clean soft rag the pot, ladle, stirrer, and funnels, and lay the sieve so as to be completely covered with turpentine, which will always keep it from gumming up. The foregoing directions concerning running the gum, and pouring in the oil, and also boiling off and mixing, are, with very little difference, to be observed in the making of all sorts of copal varnishes, except the differences of the quantities of oil, gum, &c., which will be found under the various descriptions by name, which will be hereafter described.

The choice of linned oil is of peculiar consequence to the varnish-maker. Oil from fine full-grown ripe seed, when viewed in a phial, will appear limpid, pale, and brilliant; it is mellow and sweet to the taste, has very little smell, is specifically lighter than impure oil, and, when clarified, dries quickly and firmly, and does not materially change the colour of the varnish when made, but appears limpid and brilliant.

Copal varnishes for fine paintings, &c. — Fuse 8 lbs. of the very cleanest pale African gum copal, and, when completely run fluid, pour in two gallons of hot oil, old measure; let it boil until it will string very strong; and in about fifteen minutes, or while it is yet very hot, pour in three gallons of turpentine, old measure, and got from the top of a cistern. Perhaps during the mixing, a considerable quantity of the turpentine will escape; but the varnish will be so much the brighter, transparent, and fluid; and will work freer, dry more quickly, and be very solid and durable when dry. After the varnish has been strained, if it is found too thick, before it is quite cold, heat as much turpentine, and mix with it, as will bring it to a proper consistence.

Cabinet varnish. — Fuse 7 lbs. of very fine African gum copal, and pour in half a gallon of pale clarified oil; in three or four minutes after, if it feel stringy, take it out of doors, or into another building where there is no fire, and mix with it three gallons of turpentine; afterwards strain it, and put it aside for use. This, if properly boiled, will dry in ten minutes; but if too strongly boiled, will not mix at all with the turpentine; and sometimes, when boiled with the turpentine, will mix, and yet refuse to incorporate with any other varnish less boiled than itself: therefore it requires a nicety which is only to be learned from practice. This varnish is chiefly intended for the use of japanners, cabinet-painters, coach-painters, &c.

Best body copal varnish for coach-makers, &c. — This is intended for the body parts of coaches and other similar vehicles, intended for polishing.

Fuse 8 lbs. of fine African gum copal; add two gallons of clarified oil (old measure); boil it very slowly for four or five hours, until quite stringy; mix with three gallons and a half of turpentine; strain off, and pour it into a cistern. As they are too slow in drying, coach-makers, painters, and varnish-makers, have introduced to two pots of the preceding varnish, one made as follows: —

8 lbs. of fine pale gum animé;
2 gallons of clarified oil;

3½ gallons of turpentine.
To be boiled four hours.

Quick drying body copal varnish, for coaches, &c.

(1.) 8 lbs. of the best African copal
2 gallons of clarified oil;
½ lb. of dried sugar of lead;
3½ gallons of turpentine;
Boiled till stringy, and mixed and strained.

(2.) 8 lbs. of fine gum animé;
2 gallons of clarified oil;
½ lb. of white coppers;
3½ gallons of turpentine.
Boiled as before.

To be mixed and strained while hot into the other pot. These two pots mixed together will dry in six hours in winter, and in four in summer; it is very useful for varnishing old work on dark colours, &c.

Best pale carriage varnish.

(1.) 8 lbs. 2d sorted African copal;
2½ gallons of clarified oil.
Boiled till very stringy.
½ lb. of dried coppers;
½ lb. of litharge;
5½ gallons of turpentine.
Strained, &c.

(1.) 8 lbs. of 2d sorted gum animé;
2½ gallons of clarified oil;
½ lb. of dried sugar of lead;
½ lb. of litharge;
5½ gallons of turpentine.
Mix this to the first while hot.

This varnish will dry hard, if well boiled, in four hours in summer, and in six in winter. As the name denotes, it is intended for the varnishing of the wheels, springs, and carriage parts of coaches, chaises, &c.; also, it is that description of varnish which is generally sold to and used by house-painters, decorators, &c., as from its drying quality and strong gloss, it suits their general purposes well.

Second carriage varnish.

| | | |
|-----------------------------------|--|-------------------------------|
| 8 lbs. of 2d sorted gum animé; | | ½ lb. of dried sugar of lead; |
| 2½ gallons of fine clarified oil; | | ½ lb. of dried copperas. |
| 5½ gallons of turpentine; | | Boiled and mixed as before. |
| ¼ lb. of litharge; | | |

Wainscot varnish.

| | | |
|--------------------------------|--|------------------------------------|
| 8 lbs. of 2d sorted gum animé; | | 5½ gallons of turpentine. |
| 3 gallons of clarified oil; | | To be well boiled until it strings |
| ¼ lb. of litharge; | | very strong, and then mixed and |
| ¼ lb. of dried sugar of lead; | | strained. |

Mahogany varnish is made either with the same proportions, with a little darker gum; otherwise it is wainscot varnish, with a small portion of gold size.

Black japan, is made by putting into the set-pot 48 pounds of Naples, or any other of the foreign asphaltums (except the Egyptian). As soon as it is melted, pour in 10 gallons of raw linseed oil; keep a moderate fire, and fuse 8 pounds of dark gum animé in the gum-pot; mix it with 2 gallons of hot oil, and pour it into the set-pot. Afterwards fuse 10 pounds of dark or sea amber in the 10 gallon iron pot; keep stirring it while fusing; and whenever it appears to be overheated, and rising too high in the pot, lift it from the fire for a few minutes. When it appears completely fused, mix in 2 gallons of hot oil, and pour the mixture into the set-pot; continue the boiling for 3 hours longer, and during that time introduce the same quantity of driers as before directed: draw out the fire, and let it remain until morning; then boil it until it rolls hard, as before directed: leave it to cool, and afterwards mix with turpentine.

Pale amber varnish. — Fuse 6 pounds of fine picked very pale transparent amber in the gum-pot, and pour in 2 gallons of hot clarified oil. Boil it until it strings very strong. Mix with 4 gallons of turpentine. This will be as fine as body copal, will work very free, and flow well upon any work it is applied to: it becomes very hard, and is the most durable of all varnishes; it is very excellent to mix in copal varnishes, to give them a hard and durable quality. Observe; amber varnish will always require a long time before it is ready for polishing.

Best Brunswick black. — In an iron pot, over a slow fire, boil 45 pounds of foreign asphaltum for at least 6 hours; and during the same time boil in another iron pot 6 gallons of oil which has been previously boiled. During the boiling of the 6 gallons, introduce 6 pounds of litharge gradually, and boil until it feels stringy between the fingers; then ladle or pour it into the pot containing the boiling asphaltum. Let the mixture boil until, upon trial, it will roll into hard pills; then let it cool, and mix it with 25 gallons of turpentine, or until it is of a proper consistence.

Iron-work black. — Put 48 pounds of foreign asphaltum into an iron pot, and boil for 4 hours. During the first 2 hours, introduce 7 pounds of red lead, 7 pounds of litharge, 3 pounds of dried copperas, and 10 gallons of boiled oil; add 1 eight-pound run of dark gum, with 2 gallons of hot oil. After pouring the oil and gum, continue the boiling 2 hours, or until it will roll into hard pills like japan. When cool, thin it off with 30 gallons of turpentine, or until it is of a proper consistence. This varnish is intended for blacking the iron-work of coaches and other carriages, &c.

A cheap Brunswick black. — Put 28 pounds of common black pitch, and 28 pounds of common asphaltum made from gas tar, into an iron pot; boil both for 8 or 10 hours, which will evaporate the gas and moisture; let it stand all night, and early next morning, as soon as it boils, put in 8 gallons of boiled oil; then introduce, gradually, 10 pounds of red lead, and 10 pounds of litharge, and boil for 3 hours, or until it will roll very hard. When ready for mixing, introduce 20 gallons of turpentine, or more, until of a proper consistence. This is intended for engineers, founders, ironmongers, &c.; it will dry in half an hour, or less, if properly boiled.

Axioms observed in the making of copal varnishes. — The more minutely the gum is run, or fused, the greater the quantity, and the stronger the produce. The more regular and longer the boiling of the oil and gum together is continued, the more fluid or free the varnish will extend on whatever it is applied to. When the mixture of oil and gum is too suddenly brought to whate'er by too strong a heat, the varnish requires more than its just proportion of turpentine to thin it, whereby its oily and gummy quality is reduced, which renders it less durable; neither will it flow so well in laying on. The greater proportion of oil there is used in varnishes, the less they are liable to crack, because the tougher and softer they are. By increasing the proportion of gum in varnishes,

the thicker will be the stratum, the firmer they will set solid, and the quicker they will dry. When varnishes are quite new made, and must be sent out for use before they are of sufficient age, they must always be left thicker than if they were to be kept the proper time. Varnish made from African copal alone possesses the most elasticity and transparency. Too much driers in varnish render it opaque and unfit for delicate colours. Copperas does not combine with varnish, but only hardens it. Sugar of lead does combine with varnish. Turpentine improves by age; and varnish by being kept in a warm place. All copal or oil varnishes require age before they are used.

Concluding observations. — All body varnishes are intended and ought to have 1½ lbs. of gum to each gallon of varnish, when the varnish is strained off, and cold; but as the *thinning up*, or quantity of turpentine required to bring it to its proper consistence, depends very much upon the degree of boiling the varnish has undergone, therefore, when the gum and oil have not been strongly boiled, it requires less turpentine for that purpose; whereas, when the gum and oil are very strongly boiled together, a pot of 20 gallons will require perhaps 3 gallons above the regular proportionate quantity; and if mixing the turpentine is commenced too soon, and the pot not sufficiently cool, there will be frequently above a gallon and a half of turpentine lost by evaporation.

All carriage, wainscot, and mahogany varnish ought to have fully 1 pound of gum for each gallon, when strained and cold; and should one pot require more than its proportion of turpentine, the following pot can easily be left not quite so strongly boiled; then it will require less turpentine to thin it up.

Gold sizes, whether pale or dark, ought to have fully half a pound of good gum copal to each gallon, when it is finished; and the best black japan, to have half a pound of good gum, or upwards, besides the quantity of asphaltum.

Fine mastic, or picture varnish. — Put 5 pounds of fine picked gum mastic into a new 4-gallon tin bottle; get ready 2 pounds of glass, bruised as small as barley; wash it several times; afterwards dry it perfectly, and put it into the bottle with 2 gallons of turpentine that has settled some time; put a piece of soft leather under the *bung*; lay the tin on a sack upon the counter, table, or any thing that stands solid; begin to agitate the tin, smartly rolling it backward and forward, causing the gum, glass, and turpentine, to work as if in a barrel-churn for at least 4 hours, when the varnish may be emptied out into any thing sufficiently clean, and large enough to hold it. If the gum is not all dissolved, return the whole into the bottle, and agitate as before, until all the gum is dissolved; then strain it through fine thin muslin into a clean tin bottle: leave it uncorked, so that the air can get in, but no dust; let it stand for 9 months, at least, before it is used; for the longer it is kept, the tougher it will be, and less liable to chill or bloom. To prevent mastic varnish from chilling, boil 1 quart of river sand with 2 ounces of pearl-ashes; afterwards wash the sand three or four times with hot water, straining it each time; put the sand on a soup-plate to dry, in an oven; and when it is of a good heat, pour half a pint of hot sand into each gallon of varnish, and shake it well for 5 minutes; it will soon settle, and carry down the moisture of the gum and turpentine, which is the general cause of mastic varnish chilling on paintings.

Common mastic varnish. — Put as much gum mastic, unpicked, into the gum-pot as may be required, and to every 2½ pounds of gum pour in 1 gallon of cold turpentine; set the pot over a very moderate fire, and stir it with the stirrer; be careful, when the steam of the turpentine rises near the mouth of the pot, to cover it with the carpet, and carry it out of doors, as the vapour is very apt to catch fire. A few minutes' low heat will perfectly dissolve 8 pounds of gum, which will, with 4 gallons of turpentine, produce, when strained, 4½ gallons of varnish; to which add, while yet hot, 5 pints of pale turpentine varnish, which improves the body and hardness of the mastic varnish.

Crystal varnish, may be made either in the varnish-house, drawing-room, or parlour. Procure a bottle of Canada balsam, which can be had at any druggist's; draw out the cork, and set the bottle of balsam at a little distance from the fire, turning it round several times, until the heat has thinned it; then have something that will hold as much as double the quantity of balsam; carry the balsam from the fire, and, while fluid, mix it with the same quantity of good turpentine, and shake them together until they are well incorporated: in a few days the varnish is fit for use, particularly if it is poured into a half-gallon glass or stone bottle, and kept in a gentle warmth. This varnish is used for maps, prints, charts, drawings, paper ornaments, &c.; and when made upon a larger scale, requires only warming the balsam to mix with the turpentine.

White hard spirit-of-wine varnish. — Put 5 pounds of gum sandarac into a 4-gallon tin bottle, with 2 gallons of spirits of wine, 60 over proof, and agitate it until dissolved, exactly as directed for the best mastic varnish, recollecting, if washed glass is used, that it is convenient to dip the bottle containing the gum and spirits into a copperful of hot water every 10 minutes — the bottle to be immersed only 2 minutes at a time — which will greatly assist the dissolving of the gum; but, above all, be careful to keep a firm hold over the cork of the bottle, otherwise the rarefaction will drive the cork out with the

force of a shot, and perhaps set fire to the place. The bottle, every time it is heated, ought to be carried away from the fire; the cork should be eased a little, to allow the rarefied air to escape; then driven tight, and the agitation continued in this manner until all the gum is properly dissolved; which is easily known by having an empty tin can to pour the varnish into, until near the last, which is to be poured into a gallon measure. If the gum is not all dissolved, return the whole into the 4-gallon tin, and continue the agitation until it is ready to be strained, when every thing ought to be quite ready, and perfectly clean and dry, as oily tins, funnels, strainers, or any thing damp, or even cold weather, will chill and spoil the varnish. After it is strained off, put into the varnish 1 quart of very pale turpentine varnish, and shake and mix the two well together. Spirit varnishes should be kept well corked: they are fit to use the day after being made.

Brown hard spirit varnish — is made by putting into a bottle 3 pounds of gum sandarac, with 2 pounds of shellac, and 2 gallons of spirits of wine, 60 over proof; proceeding exactly as before directed for the white hard varnish, and agitating it when cold, which requires about 4 hours' time, without any danger of fire; whereas, making any spirit varnish by heat is always attended with danger. No spirit varnish ought to be made either near a fire or by candle light. When this brown hard is strained, add 1 quart of turpentine varnish, and shake and mix it well: next day it is fit for use.

The *Chinese varnish*, comes from a tree, which grows in Cochinchina, China, and Siam. It forms the best of all varnishes.

Gold laker. — Put into a clean 4-gallon tin, 1 pound of ground turmeric, 1½ ounces of powdered gamboge, 3½ pounds of powdered gum sandarac, ¼ of a pound of shellac, and 2 gallons of spirits of wine. After being agitated, dissolved, and strained, add 1 pint of turpentine varnish, well mixed.

Red spirit laker.

2 gallons of spirits of wine;
1 pound of dragon's blood;
3 pounds of Spanish annatto;
3½ pounds of gum sandarac;
2 pints of turpentine.

Made exactly as the yellow gold laker.

Pale brass laker.

2 gallons of spirits of wine;
3 ounces of Cape aloes, cut small;
1 pound of fine pale shellac;
1 ounce gamboge, cut small.
No turpentine varnish. Made exactly as before.

But observe, that those who make lackers, frequently want some paler, and some darker, and sometimes inclining more to the particular tint of certain of the component ingredients. Therefore, if a 4-ounce phial of a strong solution of each ingredient be prepared, a laker of any tint can be produced at any time.

Preparation of linseed oil for making varnishes. — Put 25 gallons of linseed oil into an iron or copper pot that will hold at least 30 gallons; put a fire under, and gradually increase the heat, so that the oil may only simmer, for 2 hours; during that time the greatest part of its moisture evaporates; if any scum arises on the surface, skim it off, and put that aside for inferior purposes. Then increase the gradually, and sprinkle in, by a little at a time, 3 lbs. of scale litharge, 3 lbs. of good red lead, and 2 lbs. of Turkey umber, all well dried and free from moisture. If any moist driers are added, they will cause the oil to tumefy; and, at the same time, darken it, causing it to look opaque and thick, ropy and clammy, and hindering it from drying and hardening in proper time; besides, it will lie on the working painting like a piece of bladder skin, and be very apt to rise in blisters. As soon as all the driers are added to the oil, keep quietly stirring the driers from the bottom of the pot; otherwise they will burn, which will cause the oil to blacken and thicken before it is boiled enough. Let the fire be so regulated that the oil shall only boil slowly for three hours from the time all the driers were added; if it then ceases to throw up any scum, and emits little or no smoke, it is necessary to test its temperature by a few quill tops or feathers. Dip a quill top in the oil every two minutes, for when the oil is boiled enough, the quill top will crackle or curl up quite burnt; if so, draw out the fire immediately, and let the oil remain in the pot at least from 10 to 24 hours, or longer if convenient, for the driers settle much sooner when the oil is left to cool in the pot, than when it is immediately taken out.

Poppy oil. — Into four pints of pure soft water, put two ounces of foreign white vitriol; warm the water in a clean copper pan, or glazed earthen jar, until the vitriol is dissolved; pour the mixture into a clean glass or stone bottle, large enough to contain three gallons; then add to the solution of vitriol one gallon and a half of poppy oil, cork and agitate the bottle regularly and smartly for at least two hours; then pour out the contents into a wide earthenware dish: leave it at rest for eight days, when the oil will be clean and brilliant on the surface, and may be taken off with a spoon or flat skimmer, and put up in a glass bottle and exposed to the light, which in a few weeks renders the oil exceedingly limpid and colourless.

without heat, is certainly the most pale, pure, and nutritive seasoning, and retains an exquisite taste of the fruit. That designed for the arts is of inferior quality, and is plentifully imported to us from France; the heat it undergoes in its torrefaction, previous to its expression, disposes it to dry more quickly than that expressed by the cold process; but, at the same time, the heat, though it frees it from its unctuous quality, gives it more colour. When it has been extracted by the cold process, it may be prepared in the same way as directed for the poppy oil.

In the above article I have retained the workmen's names—gum, white vitriol, &c., instead of resin, sulphate of zinc, &c.

VARNISH; Green. Grind Chinese blue with double the quantity of finely powdered chromate of potash and copal varnish, thinned with turpentine. The proportions of blue and chromate may be varied. This varnish produces a striking effect on japanned goods, &c.

VEGETABLE ACIDS. The term *vegetable* is now nearly superseded by the word *organic*, though the distinction must always be maintained between acids of animal and vegetable origin.

The following are the most prominent vegetable acids.

| | | | |
|------------|----------|--------------|-----------|
| Aconitic | Citric | Krameric | Racemic |
| Acrylic | Cocinic | Lactic | Roccellic |
| Benzilic | Cominic | Meconic | Saccharic |
| Benzoic | Coumaric | Metagallic | Suberic |
| Bilic | Cuminic | Mucic | Succinic |
| Boletic | Ellagic | Nitro-picric | Tannic |
| Campholic | Erythric | Oenanthic | Tartaric |
| Camphoric | Fumaric | Paratartaric | Tartralic |
| Carbolic | Fungic | Pectic | Tartrelic |
| Cevadic | Gallic | Pyrocitric | Valeric |
| Chelidonic | Hippuric | Pyrogallic | Veratric |
| Cinnamic | Isatic | Pyrotartaric | Xanthic |
| Citraconic | Itaconic | Quinic | |

VEINS (*Filons*, Fr.; *Gänge*, Germ.); are the fissures or rents in rocks, which are filled with peculiar mineral substances, most commonly metallic ores.

VEIN STONES, or GANGUES, are the mineral substances which accompany, and frequently enclose, the metallic ores.

VELLUM, is a fine sort of PARCHMENT, which see.

VELVET (*Velours*, Fr.; *Sammet*, Germ.); a peculiar stuff, the nature of which is explained under FUSTIAN and TEXTILE FABRICS.

VENETIAN CHALK, is STRATITE.

VENTILATION, or the renewal of fresh air in stagnant places, is nowhere exhibited to such advantage as in the coal mines of Northumberland and Durham, where Mr. Buddle has carried well nigh to systematic perfection the plan of coursing the air through the winding galleries, originally contrived about the year 1760, by Mr. James Spedding, of Workington, the ablest pitman of his day.* He converted the whole of the passages into air-pipes, so to speak, drew the current of air from the downcast pit, then traversed it up and down, and round about, through the several sheaths of the workings, so that no particular gallery was left without a current of air. He thereby succeeded in actually expelling the noxious gases from the mines; those demons, which in Germany, at no remote era, were wont to be combated by the priests with impotent exorcisms or pious frauds. Before Mr. Buddle introduced his improvements, he has known the air to be led through a series of workings, thirty miles long, before it made its exit. There is in every coal mine an experienced corps, called wastemen, because they travel over the waste, or the exhausted regions, who can tell at once, by the whistling sound which the air makes at the crevices in certain partitions and doors, whether the ventilation be in good condition or not. They hear these stoppings begin to *sing* or *call* as they say, whenever an interruption takes place in any point of the labyrinthine line. Another indication of something being wrong, is when the doors get so heavy, that the boys in attendance upon them find them difficult to shut or open. The instant such a defect is discovered by any one, he cries aloud, "Holloa, there is something wrong—the doors are calling!"

In Mr. Spedding's system, the whole of the return air came in one current to his rarefying furnace (see letter c, *fig.* 1484.), whether it was at the explosive point or not. This distribution was often fraught with such danger, that a torrent of water had to be

* Mining engineers use the term *good pitman*, as admirals do *good seaman*, to denote a proficient in his calling.

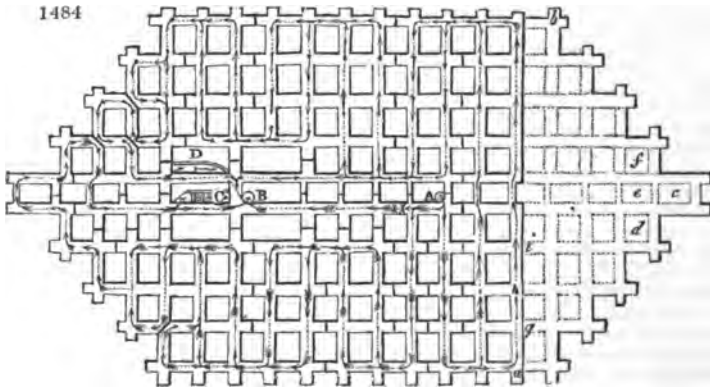
in a moment. Many explosions at that time occurred, from the furnaces above-ground, and also down through tubes from the furnaces above-ground.

About the year 1807, Mr. Buddle had his attention intensely occupied with this most important object, and then devised his plan of a divided current, carrying that portion through the active furnace *c*, *fig.* 1484., and the portion of the air from the *foul* workings of the air which, descending in the downcast pit *A*, coursed through the *clean* workings, up the dumb furnace *B*, till it reached a certain elevation in *B*, the upcast pit, above the fireplace. The pitmen had a great aversion, however, at first to adopt this plan, as they thought that the current of air, by being split, would lose its ventilating power; but they were, ere long, convinced by Mr. Buddle to the contrary. He divided the main current into two separate streams, at the bottom of the pit *A*, as shown by darts in the figure; the feathered ones, representing that part of the pit in which the course of the current of air is free from explosive mixture, or does not contain above one-thirtieth of carburetted hydrogen, as indicated by its effect upon the flame of a candle. The naked darts denote the portions of the mine where the air, being charged to the firing point, is led off towards *D*, the dumb furnace, which communicates with the hot upcast shaft, out of reach of the flame, and thence derives its power of draught. By suitable alterations in the stoppings (see the various transverse lines, and the crosses), any portion of the workings may, by the agency of the furnace, be laid out of, or brought within, the course of the vitiated current, at the pleasure of the skilful mine-viewer; so that, if he found it necessary, he could confine, by proper arrangements of his furnace, all the vitiated current to a mere gas-pipe or drift, and direct it wholly through the dumb furnace. During a practice of twenty years, Mr. Buddle had not met with any accident in consequence of a defect in the stoppings preventing the complete division of the air. The engineer has it thus within his power to detach or insulate those portions of the mine in which there is a great exudation of gas, from the rest; and, indeed, he is continually making changes, borrowing and lending currents, so to speak; sometimes laying one division or panel upon the one air-course, and sometimes upon the other, just to suit the immediate emergency. As soon as any district has ceased to be dangerous, by the exhaustion of the gas-blowers, it is transferred from the foul to the pure air-course, where gunpowder may be safely used, as also candles, instead of Davy's lamps, which give less light.

The quantity of air put down into the Wallsend colliery, at the time of the last dreadful accident, 18th June, 1835, was not less than 5000 cubic feet per minute, whence it has been justly inferred that the explosion was caused by the rashness of a wasteman carrying a light through a door into a foul drift.

Till the cutting out of the pillars commences (see the right end of the diagram), the ventilation of the several passages, boards, &c., may be kept perfect, supposing the working extending no further than *a* or *b*; because, as long as there are pillars standing,

1484



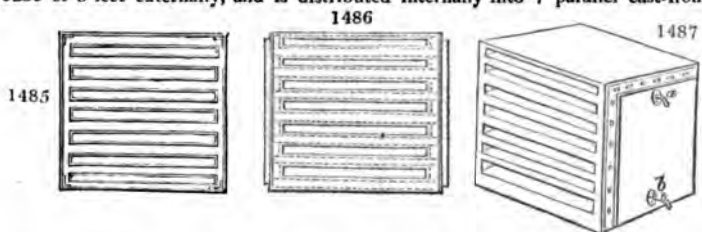
every passage may be converted into an air-conduit, for leading a current of air in any direction, either to *c*, the burning, or *D*, the dumb furnace. But the first pillar that is removed, deranges the ventilation at that spot, and takes away the means of carrying the air into the further recess towards *c*. In taking out the pillars, the miners always work to windward, that is to say, against the stream of air; so that, whatever gas may be evolved, shall be immediately carried off from the people at work. When a range

the section of the mine beyond *a, b*; and as the pillars are successively cut away to the left hand of the line *a, b*, the size of the *goaf*, or void, is increased. This vacancy is a true gas-holder, or reservoir, continually discharging itself at the points *g, h, i*, into the circulating current, to be carried off by the gas-pipe drift at the dumb furnace, but not to be suffered ever to come in contact with flame of any description. The next range of working is the line of pillars to the left of *a, b*; the coal having been entirely cleared out of the space to the right, where the place of the pillars is marked by dotted lines. The roof in the waste soon falls down, and gets fractured up to the next seam of coal, called the yard-coal seam, which, abounding in gas, sends it down in large quantities, and keeps the immense gasometer, or goaf below, continually replenished. See *Stovz*.

There are two general plans in use for at once diffusing heat and renewing the air in extensive buildings, which plans differ essentially in their principles, modes of action, and effects. The oldest, and what may be called, the *vulgar* method, consists in planting stoves in the passages or rooms to give warmth in cold weather, and in constructing large and lofty chimney-stalks, to draw air in hot weather out of the house by suction, so to speak, whereby fresh air flows in to maintain, though imperfectly, an equilibrium of pressure. In apartments, thus warmed and ventilated, the atmosphere is necessarily rarer than it is out of doors, while, in cold weather, the external air rushes in at every opening and crevice of door, window, or chimney—the fruitful source of indisposition to the inmates.

The evils resulting from the stove-heating and air-rarefying system were, a few years ago, investigated by me, in a paper read before the Royal Society*, and afterwards published in several scientific and technological journals. It is there said that the observations of *Saussure*, and other scientific travellers in mountainous regions, demonstrate how difficult and painful it is to make muscular or mental exertions in rarefied air. Even the slight rarefaction of the atmosphere, corresponding to a low state of the barometer, at the level of the sea, is sufficient to occasion languor, lassitude, and uneasiness in persons of delicate nerves; while the opposite condition of increased pressure, as indicated by a high state of the barometer, has a bracing effect upon both body and mind. Thus we see how ventilation, by the powerful draught of a high chimney stalk, as it operates by pumping out, exhausting, and attenuating the air, may prove detrimental to vivacity and health; and how ventilation, by forcing in air with a fan or a pump, is greatly to be preferred, not only for the reason above assigned, but because it prevents all regurgitation of foul air down the chimneys, an accident sure to happen in the former method. Genial air thrown in by a fan, in the basement story of a building, also prevents the stagnation of vapours from damp and miasmata, which lurk about the foundation of buildings and in sewers, and which are sucked in by the rarefying plain. Many a lordly mansion is rendered hardly tenable from such a cause, during certain vicissitudes of wind and weather.

The condensing plan, as executed by the engineers, Messrs. Easton and Amos, at the Reform Club House, consists of a large fan, revolving rapidly in a cylindrical case, and is capable of throwing 11,000 cubic feet of air per minute into a spacious subterranean tunnel, under the basement story. The fan is driven by an elegant steam-engine, worked on the expansion principle, of five horses' power. It is placed in a vault, under the flag-pavement, in front of the building; and as it moves very smoothly, and burns merely cinders from the house fires, along with some anthracite, it occasions no nuisance of any kind. The steam of condensation of the engine supplies 3 cast-iron chests with the requisite heat for warming the whole of the building. Each of these chests is a cube of 3 feet externally, and is distributed internally into 7 parallel cast-iron cases,



* I had been professionally employed by a Committee of the Officers of the Custom House, to examine the nature of the malaria which prevailed there, but I had no concern in erecting the stoves which caused it.

width. for the passage of the air transversely, as it is impelled by the fan ;

Fig. 1485, is a transverse vertical section of the steam chest, for heating the air ; *fig. 1486*, is a plan of the same ; and *fig. 1487*, is a perspective view, showing the outside casing, also the pipe *a*, for admitting the steam, and the stop-cock *b*, for allowing the condensed water to escape.

This arrangement is most judicious, economising fuel to the utmost degree ; because the steam of condensation which, in a Watt's engine, would be absorbed and carried off by the air-pump, is here turned to good account, in warming the air of ventilation during the winter months. Two hundred weight of fuel suffice for working this steam-engine during twelve hours. It pumps water for household purposes, raises the coals to the several apartments on the upper floors, and drives the fan ventilator. The air, in flowing rapidly through the series of cells, placed alternately between the steam-cases, cannot be scorched, as it is generally with air stoves ; but it is heated only to the genial temperature of from 75° to 85° Fahr., and it thence enters a common chamber of brickwork in the basement story, from which it is let off into a series of distinct flues, governed by dialled valves or registers, whereby it is conducted in regulated quantities to the several apartments of the building. I am of opinion, that it would not be easy to devise a better plan for the purpose of warming and ventilating a large house ; and I am only sorry to observe, that the plan projected by the engineers has been *injudiciously* counteracted in two particulars.

The first of these is, that the external air, which supplies the fan, is made to traverse a great heap of coke before it can enter that apparatus, whereby it suffers such friction as materially to obstruct the ventilation of the house. The following experiments, which I made recently upon this point, will place the evil in a proper light : — Having fitted up Dr. Wollaston's differential barometer, as an anemometer, with oil, of specific gravity 0.900 in one leg of its syphon, and water of 1.000 in the other, covered with the said oil in the two cisterns at top, I found that the stream of air produced by the fan, in a certain part of the flue, had a velocity only as the number 8, while the air was drawn through the coke, but that it had a velocity in the same place as the number 11, whenever the air was freely admitted to the fan by opening a side door. Thus, three-elevenths, both of the ventilating and warming effect of the fan, are lost. I cannot divine any good reason for making the members of the Reform Club breathe an atmosphere, certainly not improved, but most probably vitiated, by being passed in a moist state through a porous sulphurous carbon, whereby it will tend to generate the two deleterious gases, carbonic oxide and sulphuretted hydrogen, in a greater or less degree. It is vain to allege that these gases may not be discoverable by chemical analysis — can the gaseous matters, which generate cholera, yellow fever, or ague, be detected by chemical re-agents ? No, truly ; yet every one admits the reality of their specific virus. I should propose that the air be transmitted through a large sheet of wire-cloth before it reaches the fan, whereby it would be freed from the grosser particles of soot that pollute the atmosphere of London. The wire-cloth should be brushed every morning.

The second particular, which counteracts in some measure the good effects of the fan in steam ventilation, is the huge stove placed in the top story of the building. This potent furnace, consuming, when in action, 3 cwt. of coals per day, tends to draw down foul air, for its own supply, from the chimneys of the adjoining rooms, and thus to impede the upward current created by the fan. I have measured, by Dr. Wollaston's differential barometer, the ventilating influence of the said furnace stove, and find it to be perfectly insignificant, — nay, most absurdly so, — when compared with the fan, as to the quantity of fuel which each requires per day. The rarefaction of air in the stove chamber, in reference to the external air, was indicated by a quarter of an inch difference of level in the legs of the oil and water syphon, and this when the door of the stove-room was shut, as it usually is ; the tube of the differential barometer being inserted in a hole in the door. The fan indicates a ventilating force equal to 2 inches of the water syphon, which is 20 inches of the above oil and water syphon, and therefore 80 times greater than that of the stove furnace ; so that, taking into view the smaller quantity of fuel which the fan requires, the advantage in ventilation, in favour of the fan, is the enormous ratio of 120 to 1, at the lowest estimate. The said stove, in the attic, seems to me to be not only futile, but dangerous. It is a huge rectangular cast-iron chest, having a large hopper in front, kept full of coals, and it is contracted above into a round pipe, which discharges the burnt air and smoke into a series of horizontal pipes of cast-iron, about 4 inches diameter, which traverse the room under the ceiling, and terminate in a brick chimney. In consequence of this obstruction, the draught through the furnace is so feeble, that no rush of air can be perceived in its ash-pit, even when this is contracted to an area of 6 inches square ; — nay, when the ash-pit was momentarily luted with bricks and clay, and the tube of the differential barometer

was introduced a little way under the grate, the level of the oil and water syphon in that instrument was displaced by no more than one-tenth of an inch, which is only one-hundredth of an inch of water, — a most important effect under a daily consumption of 3 cwt. of coals. In fact, this stove may be fitly styled an *incendiary coal devourer*, as it has already set fire to the house; and though now laid upon a new floor of iron rafters and stone flags, it still offers so much danger from its outlet iron pipes, should they become ignited from the combustion of charcoal deposited in them, that I think no premium of insurance adequate to cover the imminent risk of fire. The stove being, therefore, a superfluous and dangerous nuisance, should be turned out of doors as speedily as possible. Its total cost, with that of its fellow in the basement story, cannot be much less than the cost of the steam-engine, with all its truly effectual warming and ventilating appurtenances.

I take leave to observe, that the system of heating and ventilating apparatus, constructed by Messrs. Easton and Amos, in the Reform Club House, offers one striking and peculiar advantage. It may be modified at little expense, so as to become the ready means of introducing, during the sultriest dog days, refreshing currents of air, at a temperature of 10, 20, 30, or even 40 degrees under that of the atmosphere. An apparatus of this nature, attached to the Houses of Parliament and courts of law, would prove an inestimable blessing to our legislators, lawyers, judges, and juries. Of such cool air a very gentle stream would suffice to make the most crowded apartments comfortable, without endangering the health of their inmates with gusts of wind through the doors, windows, and floors.

It is lamentable to reflect how little has been done for the well-being of the sentient and breathing functions of man in the public buildings of the metropolis, notwithstanding our boasted march of intellect and diffusion of useful knowledge. Almost all our churches are filled on Sundays with stove-roasted air; and even the House of Commons has its atmosphere exhausted by the suction of a huge chimney stalk, with a furnace equal, it is said, to that of a 40-horse steam boiler. To gentlemen plunged in air so attenuated, condensation of thought and terseness of expression can hardly be the order of the day.

Nearly twenty years have elapsed since I endeavoured to point public attention to this important subject in the following terms: — “Our legislators, when bewailing, not long ago, the fate of their fellow-creatures, doomed to breathe the polluted air of a factory, were little aware how superior the system of ventilation adopted in many cotton mills was to that employed for their own comfort in either House of Parliament. The engineers of Manchester do not, like those of the metropolis, trust for a sufficient supply of fresh air into any crowded hall, to currents physically created in the atmosphere by the difference of temperature excited by chimney draughts, because they know them to be ineffectual to remove, with requisite rapidity, the dense carbonic acid gas generated by many hundred powerful lungs.”* At page 382. of the work just quoted, there is an exact drawing and description of the factory ventilating fan.

On the 6th of June, 1836, I took occasion again, in a paper read before the Royal Society, upon the subject of the *malaria* which then prevailed in the Custom House, to investigate the principles of ventilation by the fan, and to demonstrate, by a numerous train of experiments, the great preference due to it, as to effect, economy, and comfort, over chimney-draught ventilation. Yet at this very time, the latter most objectionable plan was in progress of construction, upon a colossal scale, for the House of Commons. About the same period, however, the late ingenious Mr. Oldham, engineer of the Bank of England, mounted a mechanical ventilator and steam-chest heater, for supplying a copious current of warm air to the rooms of the engraving and printing departments of that establishment. Instead of a fan, Mr. Oldham employed a large pump to force the air through the alternate cells of his steam chest. He had introduced a similar system into the Bank of Ireland about ten years before, which is now in full action.

About two years ago, Messrs. Easton and Amos were employed to ventilate the letter carriers' and inland office departments of the General Post Office, of which the atmosphere was rendered not only uncomfortable but insalubrious, by the numerous gas lights required there in the evenings. This task has been executed to the entire satisfaction of their employers, by means of fans driven by steam engine power. The said engineers made, about the same time, a set of machinery similar to that erected at the Bank of England, for warming and ventilating the Bank of Vienna. They are justly entitled to the credit of having been the first to execute, in all its bearings, the system of heating and ventilating buildings, having special respect to the health of their inmates, which I urged upon the public mind many years ago.

As fans of sufficient size, driven by steam power with sufficient velocity to warm in winter, and ventilate at all times, the most extensive buildings, may be erected upon the

* *Philosophy of Manufactures*, p. 380., published by Charles Knight. — London, 1836.

principles above described, without causing any nuisance from smoke, it is to be hoped that the Chapel of Henry VII. will not be desecrated by having a factory Vesuvius reared in its classical precincts, and that the noble pile of architecture of the new Houses of Parliament will not be disfigured with such a phenomenon.

The cheering and bracing action of condensed air, and the opposite effects of rarefied air upon human beings, formed the subject of several fine physiological experiments, made a few years ago by M. Junot, and described by him in the 9th volume of the *Archives Generales de Medecine*: — "When a person is placed," says he, "in condensed air, he breathes with a new facility; he feels as if the capacity of his lungs were enlarged; his respirations become deeper and less frequent; he experiences, in the course of a short time, an agreeable glow in his chest, as if the pulmonary cells were becoming dilated with an elastic spirit, while the whole frame receives, at each inspiration, fresh vital impulsion. The functions of the brain get excited, the imagination becomes vivid, and the ideas flow with a delightful facility; digestion is rendered more active, as after gentle exercise in the air, because the secretory organs participate immediately in the increased energy of the arterial system, and there is therefore no thirst."

In rarefied air the effects on the living functions are just the reverse. The breathing is difficult, feeble, frequent, and terminates in an asthmatic paroxysm; the pulse is quick and most compressible; hæmorrhages often occur, with tendency to fainting; the secretions are scanty or totally suppressed, and at length apathy supervenes.

These striking results obtained on one individual at a time, with a small experimental apparatus, have been recently reproduced, on a working scale, with many persons at once enclosed in a mining shaft, encased with strong tubing, formed of a series of large sheet-iron cylinders, riveted together, and sunk to a great depth through the bed of the river Loire, near Languin. The seams of coal, in this district of France, lie under a stratum of quicksand, from 18 to 20 metres thick, (20 to 22 yards,) and they had been found to be inaccessible by all the ordinary modes of mining previously practised. The obstacle had been regarded to be so perfectly insurmountable, that every portion of the great coal basin, that extends under these alluvial deposits, though well known for centuries, had remained untouched. To endeavour, by the usual working, to penetrate through these semi-fluid quicksands, which communicate with the waters of the Loire, was, in fact, nothing less than to try to sink a shaft in that river, or to drain the river itself. But this difficulty has been successfully grappled with, through the resources of science, boldly applied by M. Triger, an able civil engineer.

By means of the above frame of iron tubing, furnished with an air-tight ante-chamber at its top, he has contrived to keep his workmen immersed in air, sufficiently condensed by forcing-pumps, to repel the water from the bottom of the iron cylinders, and thereby to enable them to excavate the gravel and stones to a great depth. The compartment at top has a man-hole door in its cover, and another in its floor. The men, after being introduced into it, shut the door over their heads, and then turn the stop-cock upon a pipe, in connexion with the condensed air in the under shaft. An equilibrium of pressure is soon established in the ante-chamber, by the influx of the dense air from below, whereby the man-hole door in the floor may be readily opened, to allow the men to descend. Here they work in air, maintained at a pressure of three atmospheres, by the incessant action of leathern valved pumps, driven by a steam engine. While the dense air thus drives the waters of the quicksand, communicating with the Loire, out of the shaft, it infuses at the same time such energy into the miners, that they can easily excavate double the work without fatigue which they could do in the open air. Upon many of them the first sensations are painful, especially upon the ears and eyes, but ere long they get quite reconciled to the bracing element. Old asthmatic men become here effective operatives; deaf persons recover their hearing, while others are sensible to the slightest whisper. The latter phenomenon proceeds from the stronger pulses of the dense air upon the membrane of the drum of the ear.

Much annoyance was at first experienced from the rapid combustion of the candles, but this was obviated by the substitution of flax for cotton thread in the wicks. The temperature of the air is raised a few degrees by the condensation.

Men, who descend to considerable depths in diving bells, experience an augmentation of muscular energy, similar to that above described. They thereby acquire the power of bending over their knees strong bars of iron, which they would find quite inflexible by their utmost efforts when drawn up to the surface.

These curious facts clearly illustrate and strongly enforce the propriety of ventilating apartments by means of condensed air, and not by air rarefied with large chimney draughts, as has been hitherto most injudiciously, wastefully, and filthily done, in too many cases.

As the subject of ventilating and warming the public buildings in Liverpool, and particularly the new Custom-house, has been under discussion, we extract from the *Architectural Journal* the following paper by Mr. C. W. Williams.

"Doctor Ure, in his inquiry into the modes of warming and ventilating, observes,

that 'the great principle of ventilation is, never to present the same portion of air twice over to the human lungs, but to supply them at each fresh inspiration with pure aerial particles in a genial thermometric and hygrometric condition.'

"Where heating is alone attended to, as in the case of heat conveyed by steam, in metal pipes, it becomes necessary to provide currents of cold air, to supply the required continued change in the apartments for the purposes of ventilation. It is manifest then, that the best principle must be, first, to heat the required volume of fresh air, and then to introduce it to the apartments to be heated and ventilated, instead of effecting this double object by two distinct processes. The *modus operandi* is as follows:—A body of pure air, of any required volume, and passing at any required velocity, is forced, by the aid of an air-condensing pump, into a chamber or chest, where it is heated in an ingeniously contrived, but extremely simple apparatus, by means of cross currents of steam. The peculiarity of this contrivance is, that an ascending body of air, on entering this chest, divides itself spontaneously into any required number of thin horizontal films, by which a very extending surface is exposed to corresponding steam-heated metal surfaces. Instead, therefore, of passing the steam through a series of pipes, along which, but in an opposite direction, the condensed water has to return, it is conveyed at once from the boiler into the chest or condenser, (which, in fact, it is,) where, on having parted with its heat to the air as above described, it is condensed, and returned directly to the boiler. The chest or condenser, in the apparatus at the Bank of England, is but 3 feet square, yet the body of air to be heated, while passing over but 3 lineal feet, spreads itself over no less than 154 superficial feet, and, coming in contact with a corresponding superficies, heated by the steam, it necessarily receives a very large supply of heat in a short space of time.

"The apparatus in the Bank of England, independently of heating and ventilating several large apartments, is put to the severest test, namely, that of evaporating the moisture from a series of 400 large mill-boards, with a surface of 1600 feet, and which moisture they have absorbed from the fresh-printed bank notes which are daily dried by this process.

"With respect to the quantity of heat which this small apparatus is capable of imparting to the air, this is accurately tested by the quantity of water which is condensed, and which amounts hourly to twelve gallons.

"Of the efficacy of an artificial current produced by means of a fan or cylinder, Dr. Ure observes, that 'it has been ascertained that a power equivalent to one horse, in a steam engine, will drive at the rate of 80 feet per second a fan, the effective surfaces of whose vanes, and whose inhaling conduits, have each an area of 18 inches square, equal to that of a large steam boiler chimney. The velocity of air in the chimney, produced by a consumption of fuel equivalent to the power of twenty horses was no more than 35 feet per second; while that of the fan, as impelled by the power of one horse, was 66 feet per second. Hence it appears that the economy of ventilation by the fan is to that by the chimney draught, as 66×20 is to 35, or 38 to 1. It is obvious, therefore, that, with one bushel of coals consumed in working a steam-impelled excentric fan, we can obtain as great a degree of ventilation, or we can displace as great a volume of air, as we could with 38 bushels of coals consumed in creating a chimney draught. Economy, cleanliness, and compactness of construction are not, however, the sole advantages which the mechanical system of ventilation possesses over the physical. It is infallible, even under such vicissitudes of wind and weather as would essentially obstruct any chimney draught ventilation, because it discharges the air with a momentum quite eddy proof; and it may be increased, diminished, or stopped altogether, in the twinkling of an eye, by the mere shifting of a band from one pulley to another. No state of atmosphere without, no humidity of air within, can resist its power. It will impel the air of a crowded room, loaded with the vesicular vapours of perspiration, with equal certainty as the driest and most expansive."

After so clear and practical an exposition of the advantages of a current, mechanically created, nothing further need be said of natural currents arising from mere increase of temperature, excepting that, by the adoption of the pump instead of the fan, a very considerable power is saved, and the operation performed much more effectively.

Another peculiarity of Mr. Oldham's apparatus here merits attention. The large volume of air heated and passed off to the required apartments is, previously to its being received into the heating chest, filtered and purified, by being deprived of all that noxious floating matter with which the atmosphere, particularly that of London, is at all times charged, and which, if heated and sent into the apartments with the air, would but increase that noxious character, and render it still more injurious to the respiration of human beings. Not only, indeed, are these offensive impurities which are floating in the atmosphere effectually separated, but a power is given of charging it with aromatic or antiseptic matter, thus rendering it not only the medium of warmth and ventilation, but of purifying and healthful influences."

VENUS, is the mythological name of copper

VERATRINE, is a vegetable alkali, of a poisonous nature, extracted from the seeds of the *Veratrum sabadilla*, the roots of the *Veratrum album*, or white hellebore, and of *Colchicum autumnale*, or meadow saffron, in which plants it exists combined chiefly with gallic acid. It is obtained in the form of a white powder. It has an acrid, burning taste, but without any bitterness; it has no smell; but when snuffed into the nostrils, it excites violent and dangerous sneezing. It melts at a heat of 122° F., and concretes, on cooling, into a transparent yellowish mass. It restores the blue colour of reddened litmus paper. It is hardly soluble in water or ether, but abundantly in alcohol. It consists of—carbon 66·75, hydrogen 8·54, nitrogen 5·04, and oxygen 19·60. Its saline compounds have an acrid and burning taste. Veratrine resembles strychnine and brucine, in its effects upon living bodies, producing tetanus and death in a moderate dose; notwithstanding which, it has been prescribed by some of our poison doctors, especially mixed with hog's lard, in the form of frictions on the forehead, for nervous maladies; but seldom, I believe, with any good effects.

VERDIGRIS. (*Vert-de-gris*, Fr.; *Grünspan*, Germ.) The copper used in this manufacture, is formed into round sheets, from 20 to 25 inches diameter, by one twenty-fourth of an inch in thickness. Each sheet is then divided into oblong squares, from 4 to 6 inches in length, by 3 broad; and weighing about 4 ounces. They are separately beaten upon an anvil, to smooth their surfaces, to consolidate the metal, and to free it from scales. The refuse of the grapes, after the extraction of their juice, formerly thrown on to the dunghill, is now preserved for the purpose of making verdigris. It is put loosely into earthen vessels, which are usually 16 inches high, 14 in diameter at the widest part, and about 12 at the mouth. The vessels are then covered with lids, which are surrounded by straw mats. In this situation the materials soon become heated, and exhale an acid odour; the fermentation beginning at the bottom of the cask, and gradually rising till it actuate the whole mass. At the end of two or three days, the manufacturer removes the fermenting materials into other vessels, in order to check the process, lest putrefaction should ensue. The copper plates, if new, are now prepared, by rubbing them over with a linen cloth dipped in a solution of verdigris; and they are laid up alongside of one another to dry. If the plates are not subjected to this kind of preparation, they will become black, instead of green, by the first operation. When the plates are ready, and the materials in a fermenting state, one of them is put into the earthen vessel for 24 hours, in order to ascertain whether it be a proper period to proceed to the remaining part of the process. If, at the end of this period, the plate be covered with an uniform green layer, concealing the whole copper, every thing is right; but if, on the contrary, liquid drops hang on the surface of the metal, the workmen say the plates are sweating, and conclude that the heat of the fermented mass has been inadequate; on which account another day is allowed to pass before making a similar trial. When the materials are finally found to be ready, the strata are formed in the following manner. The plates are laid on a horizontal wooden grating, fixed in the middle of a vat, on whose bottom a pan full of burning charcoal is placed, which heats them to such a degree, that the women who manage this work are obliged to lay hold of them frequently with a cloth when they lift them out. They are in this state put into earthen vessels, in alternate strata with the fermented materials, the uppermost and undermost layers being composed of the expressed grapes. The vessels are covered with their straw mats, and left at rest. From 30 to 40 pounds of copper are put into one vessel.

At the end of 10, 12, 15, or 20 days the vessels are opened, to ascertain, by the materials having become white, if the operation be completed.

Detached glossy crystals will be perceived on the surface of the plates; in which case the grapes are thrown away, and the plates are placed upright in a corner of the verdigris cellar, one against the other, upon pieces of wood laid on the ground. At the end of two or three days they are moistened by dipping in a vessel of water, after which they are replaced in their former situation, where they remain seven or eight days, and are then subjected to momentary immersion, as before. This alternate moistening and exposure to air is performed six or eight times, at regular intervals of about a week. As these plates are sometimes dipped into damaged wine, the workmen term these immersions, *one wine, two wines, &c.*

By this treatment, the plates swell, become green, and covered with a stratum of verdigris, which is readily scraped off with a knife. At each operation every vessel yields from five to six pounds of verdigris, in a *fresh* or *humid* state; which is sold to wholesale dealers, who dry it for exportation. For this purpose, they knead the paste in wooden troughs, and then transfer it to leathern bags, a foot and a half long, and ten inches in diameter. These bags are exposed to the sun and air till the verdigris has attained a sufficient degree of hardness. It loses about half its weight in this operation; and it is said to be knife-proof, when this instrument, plunged through the leathern bag, cannot penetrate the loaf of verdigris.

farm-houses there is a verdigris cellar; and its principal operations are conducted by the females of the family. They consider the forming the strata, and scraping off the verdigris, the most troublesome part. Chaptal says that this mode of making verdigris would admit of some improvements: for example, the acetification requires a warmer temperature than what usually arises in the earthen vessels; and the plates, when set aside to generate the coat of verdigris, require a different degree of heat and moisture from that requisite for the other operations.

Verdigris is a mixture of the crystallized acetate of copper and the sub-acetate, in varying proportions. According to Vauquelin's researches, there are three compounds of oxide of copper and acetic acid; 1. a subacetate, insoluble in water, but decomposing in that fluid, at common temperatures changing into peroxide and acetate; 2. a neutral acetate, the solution of which is not altered at common temperatures, but is decomposed by ebullition, becoming peroxide and superacetate; and, 3. superacetate, which in solution is not decomposed, either at common temperatures or at the boiling point; and which cannot be obtained in crystals, except by slow spontaneous evaporation, in air or *in vacuo*. The first salt, in the dry state, contains 66.51 of oxide; the second, 44.44; and the third, 33.34.

Mr. Phillips has given the following analyses of French and English verdigris; *Annals of Philosophy*, No. 21. —

| | French Verdigris. | English Verdigris. |
|----------------------|-------------------|--------------------|
| Acetic acid - | - 29.3 | 29.62 |
| Peroxide of copper - | - 43.5 | 44.25 |
| Water - | - 25.2 | 25.51 |
| Impurity - | - 2.0 | 0.62 |
| | 100.0 | 100.00 |

Distilled verdigris, as it was long erroneously called, is merely a *binacetate* or superacetate of copper, made by dissolving, in a copper kettle, one part of verdigris in two of distilled vinegar; aiding the mutual action by slight heat and agitation with a wooden spatula. When the liquor has taken its utmost depth of colour, it is allowed to settle, and the clear portion is decanted off into well glazed earthen vessels. Fresh vinegar is poured on the residuum, and if its colour does not become deep enough, more verdigris is added. The clear and saturated solution is then slowly evaporated, in a vessel kept uniformly filled, till it acquires the consistence of syrup, and shows a pellicle on its surface; when it is transferred into glazed earthen pans, called *oulas* in the country. In each of these dishes, two or three sticks are placed, about a foot long, cleft till within two inches of their upper end, and having the base of the cleft kept asunder by a bit of wood. This kind of pyramid is suspended by its summit in the liquid. All these vessels are transported into crystallizing rooms, moderately heated with a stove, and left in the same state for 15 days, taking care to maintain an uniform temperature. Thus are obtained very fine groups of crystals of acetate of copper, clustered round the wooden rods; on which they are dried, taken off, and sent into the market. They are distinctly rhomboidal in form, and of a lively deep blue colour. Each cluster of crystals weighs from five to six pounds; and, in general, their total weight is equal to about one-third of the verdigris employed.

The crystallized binacetate of commerce consists, by my analysis, of—acetic acid, 52; oxide of copper, 39.6; water, 8.4, in 100. I have prepared crystals which contain no water. There is a triple acetate of copper and lime, which resembles distilled verdigris in colour. It was manufactured pretty extensively in Scotland some years ago, and fetched a high price, till I published an analysis of it in the *Edinburgh Philosophical Journal*. It is much inferior, for all uses in the arts, to the proper binacetate.

VERDITER, or BLUE VERDITER. This is a precipitate of oxide of copper with lime, made by adding that earth, in its purest state, to the solution of nitrate of copper, obtained in quantities by the refiners, in parting gold and silver from copper by nitric acid. The cupreous precipitate must be triturated with lime, after it is nearly dry, to bring out the fine velvety blue colour. The process is delicate, and readily misgives in unskilful hands.

The *centres bleues en pâte* of the French, though analogous, are in some respects a different preparation. To make it, dissolve sulphate of copper in hot water, in such proportions that the liquid may have a density of 1.3. Take 240 pound measures of this solution, and divide it equally into 4 open-headed casks; add to each of these 45 pound measures of a boiling-hot solution of muriate of lime, of specific gravity 1.317, whereby a double decomposition will ensue; with the formation of muriate of copper and sulphate of lime, which precipitates. It is of consequence to work the materials well together at the moment of mixture, to prevent the precipitate agglomerating in unequal masses.

After leaving it to settle for 12 hours, a small quantity of the clear liquor may be examined, to see whether the just proportions of the two salts have been employed, which is done by adding either sulphate of copper or muriate of lime. Should either cause much precipitation, some of the other must be poured in till the equivalent decomposition be accomplished; though less harm results from an excess of sulphate of copper than of muriate of lime.

The muriate of copper is to be decanted from the subsided gypsum, which must be drained and washed in a filter; and these blue liquors are to be added to the stronger; and the whole distributed, as before, into 4 casks; composing in all 670 pound measures of a green liquor, of 1.151 specific gravity.

Meanwhile, a magma of lime is to be prepared as follows: — 100 pounds of quicklime are to be mixed up with 300 pounds of water, and the mixture is to be passed through a wire-gauze sieve, to separate the stony and sandy particles, and then to be ground in a proper mill to an impalpable paste. About 70 or 80 pounds of this mixture (the beauty of the colour is inversely as the quantity of lime) are to be distributed in equal portions between the four casks, strongly stirring all the time with a wooden spatula. It is then left to settle, and the limpid liquor is tested by ammonia, which ought to occasion only a faint blue tinge; but if the colour be deep blue, more of the lime paste must be added. The precipitate is now to be washed by decantation, employing for this purpose the weak washings of a former operation; and it is lastly to be drained and washed on a cloth filter. The proportions of material prescribed above furnish from 500 to 540 pounds of green paste.

Before making further use of this paste, the quantity of water present in it must be determined by drying 100 or 200 grains. If it contain 27 per cent. of dry matter, 12 pounds of it may be put into a wooden bucket (and more or less in the ratio of 12 to 27 per cent.) capable of containing 17½ pints; a pound (measure) of the lime paste is then to be rapidly mixed into it; immediately afterwards, a pint and a quarter of a watery solution of the pearlsh of commerce, of spec. grav. 1.114, previously prepared; and the whole mixture is to be well stirred, and immediately transferred to a colour-mill. The quicker this is done, the more beautiful is the shade.

On the other hand, two solutions must have been previously made ready, one of sal-ammoniac (4 oz. troy dissolved in 3½ pints of water), and another of sulphate of copper (8 oz. troy dissolved in 3½ pints of water).

When the paste has come entirely through the mill, it is to be quickly put into a jar, and the two preceding solutions are to be simultaneously poured into it; when a cork is to be inserted, and the jar is to be powerfully agitated. The cork must now be secured with a fat lute. At the end of four days this jar and three of its fellows are to be emptied into a large hogshhead nearly full of clear water, and stirred well with a paddle. After repose, the supernatant liquid is run off; when it is filled up again with water, and elutriated several times in succession, till the liquid no longer tinges turmeric paper brown. The deposit may be then drained on a cloth filter. The pigment is sold in the state of a paste; and is used for painting, or printing paper-hangings for the walls of apartments.

The above prescribed proportions furnish the superfine blue paste: for the second quality, one-half more quicklime paste is used; and for the third, double of the lime and sal ammoniac; but the mode of preparation is in every case the same.

This paste may be dried into a blue powder, or into crayons for painters, by exposing it on white deals to a very gentle heat in a shady place. This is called *cendres bleues en pierre*.

VERDITER, or BREMEN GREEN. This pigment is a light powder, like magnesia, having a blue or bluish green colour. The first is most esteemed. When worked up with oil or glue, it resists the air very well; but when touched with lime, it is easily affected, provided it has not been long and carefully dried. A strong heat deprives it of its lustre, and gives it a brown or blackish-green tint.

The following is, according to M. J. G. Gentele, the process of fabrication in Bremen, Cassel, Eisenach, Minden, &c.: —

a. 225 lbs. of sea salt, and 222 lbs. of blue vitriol, both free from iron, are mixed in the dry state, then reduced between mill-stones with water to a thick homogeneous paste.

b. 225 lbs. of plates of old copper are cut by scissors into bits of an inch square, then thrown and agitated in a wooden tub containing 2 lbs. of sulphuric acid, diluted with a sufficient quantity of water, for the purpose of separating the impurities; they are afterwards washed with pure water in casks made to revolve upon their axis.

c. The bits of copper being placed in oxidation-chests, along with the magma of common salt and blue vitriol previously prepared in strata of half an inch thick, they are left for some time to their mutual reaction. The above chests are made of oaken

planks joined without iron nails, and set aside in a cellar, or other place of moderate temperature.

The saline mixture, which is partially converted into sulphate of soda and chloride of copper, absorbs oxygen from the air, whereby the metallic copper passes into a hydrated oxide, with a rapidity proportioned to the extent of the surfaces exposed to the atmosphere. In order to increase this exposure, during the three months that the process requires, the whole mass must be turned over once every week, with a copper shovel, transferring it into an empty chest alongside, and then back into the former one.

At the end of three months, the corroded copper scales must be picked out, and the saline particles separated from the slimy oxide with the help of as little water as possible.

d. This oxidized *schalm*, or mud, is filtered, then thrown, by means of a bucket containing 30 pounds, in a tub, where it is carefully divided or comminuted.

e. For every six pailfuls of *schalm* thus thrown into the large tub, 12 pounds of muriatic acid, at 15° Baumé, are to be added; the mixture is to be stirred, and then left at rest for 24 or 36 hours.

f. Into another tub, called the blue back, there is to be introduced, in like manner, for every six pailfuls of the acidified *schalm*, 15 similar pailfuls of a solution of colourless clear caustic alkali, at 19° Baumé.

g. When the back (e) has remained long enough at rest, there is to be poured into it a pailful of pure water for every pailful of *schalm*.

A. When all is thus prepared, the set of workmen who are to empty the back (e), and those who are to stir (f), must be placed alongside of each. The first set transfer the *schalm* rapidly into the latter back; where the second set mix and agitate it all the time requisite to convert the mass into a consistent state, and then leave it at rest from 36 to 48 hours.

The whole mass is to be now washed; with which view it is to be stirred about with the affusion of water, allowed to settle, and the supernatant liquor is drawn off. This process is to be repeated till no more traces of potash remain among the blue. The deposit must be then thrown upon a filter, where it is to be kept moist, and exposed freely to the air. The pigment is now squeezed in the filter-bags, cut into bits, and dried in the atmosphere, or at a temperature not exceeding 78° Fahr. It is only after the most complete desiccation that the colour acquires its greatest lustre.

VERMICELLI is a paste of wheat flour, drawn out and dried in slender cylinders, more or less tortuous, like worms, whence the Italian name. The *grau* of the French is wheat coarsely ground, so as to free it from the husk; the hardest and whitest part, being separated by sifting, is preferred for making the finest bread. When this *grau* is a little more ground, and the dust separated from it by the boulting-machine, the granular substance called *semoule* is obtained, which is the basis of the best paste. The softest and purest water is said to be necessary for making the most plastic vermicelli dough; 12 pounds of it being usually added to 50 pounds of *semoule*. It is better to add more *semoule* to the water, than water to the *semoule*, in the act of kneading. The water should be hot, and the dough briskly worked while still warm. The Italians pile one piece of this dough upon another, and then tread it well with their feet for two or three minutes. They afterwards work it for two hours with a powerful rolling-pin, a bar of wood from 10 to 12 feet long, larger at the one end than the other, having a sharp cutting edge at the extremity, attached to the large kneading-trough.

When the dough is properly prepared, it is reduced to thin ribands, cylinders, or tubes, to form vermicelli and macaroni of different kinds. This operation is performed by means of a powerful press. This is vertical, and the iron plate or follower carried by the end of the screw fits exactly into a cast-iron cylinder, called the *bell*, like a sausage-machine, of which the bottom is perforated with small holes, of the shape and size intended for the vermicelli. The *bell* being filled, and warmed with a charcoal fire to thin the dough into a paste, this is forced slowly through the holes, and is immediately cooled and dried by a fanmer as it protrudes. When the threads or fillets have acquired the length of a foot, they are grasped by the hand, broken off, and twisted, while still flexible, into any desired shape upon a piece of paper.

The macaroni requires to be made of a less compact dough than the vermicelli. The former is forced through the perforated bottom, usually in fillets, which are afterwards formed into tubes by joining their edges together before they have had time to become dry. The *luzagnes* are macaroni left in the fillet or riband shape.

Vermicelli is made with most advantage from the flour of southern countries, which is richest in gluten. It may also be made from our ordinary flour, provided an addition of gluten be made to the flour paste. Vermicelli prepared from ordinary flour is apt

to melt into a paste when boiled in soups. It may, however, be well made economically by the following prescription : —

| | | | | |
|----------------------------|---|---|---|---------|
| Vermicelli or Naples flour | - | - | - | 21 lbs. |
| White potato flour | - | - | - | 14 — |
| Boiling water | - | - | - | 12 — |
| Total | | | | 47 lbs. |

Affording 45 lbs. of dough, and 30 of dry vermicelli. With gluten, made from common flour, the proportions are : —

| | | | | |
|----------------|---|---|---|---------|
| Flour as above | - | - | - | 30 lbs. |
| Fresh gluten | - | - | - | 10 — |
| Water | - | - | - | 7 — |
| Total | | | | 47 lbs. |

Affording 30 lbs. of dry vermicelli or macaroni.

VERMILLION, or *Cinnabar*, is a compound of mercury and sulphur in the proportion of 100 parts of the former to 16 of the latter, which occurs in nature as a common ore of quicksilver, and is prepared by the chemist as a pigment, under the name of Vermillion. It is, properly speaking, a bisulphuret of mercury. This artificial compound being extensively employed, on account of the beauty of its colour, in painting, for making red sealing-wax, and other purposes, is the object of an important manufacture. When vermilion is prepared by means of sublimation, it concretes in masses of considerable thickness, concave on one side, convex on the other, of a needle-form texture; brownish-red in the lump, but when reduced to powder of a lively red colour. On exposure to a moderate heat, it evaporates without leaving a residuum, if it be not contaminated with red lead; and at a higher heat, it takes fire, and burns entirely away, with a blue flame.

Holland long kept a monopoly of the manufacture of vermilion, from being alone in possession of the art of giving it a fine flame colour. Meanwhile the French chemists examined this product with great care, under an idea that the failure of other nations to rival the Dutch arose from ignorance of its true composition; some, with Berthollet, imagined that it contained a little hydrogen; and others, with Fourcroy, believed that the mercury contained in it was oxidized; but, eventually, Seguin proved that both of these opinions were erroneous; having ascertained, on the one hand, that no hydrogenous matter was given out in the decomposition of cinnabar, and on the other that sulphur and mercury, by combining, were transformed into the red sulphuret in close vessels, without the access of any oxygen whatever. It was likewise supposed that the solution of the problem might be found in the difference of composition between the red and black sulphurets of mercury; and many conjectures were made with this view, the whole of which were refuted by Seguin. He demonstrated, in fact, that a mere change of temperature was sufficient to convert the one sulphuret into the other, without occasioning any variation in the proportion of the two elements. Cinnabar, moderately heated in a glass tube, is convertible into ethiops, which in its turn is changed into cinnabar by exposing the tube to a higher temperature; and thence he was led to conclude that the difference between these two sulphurets was owing principally to the state of the combination of the constituents. It would seem to result from all these researches, that cinnabar is only an intimate compound of pure sulphur and mercury, in the proportions pointed out by analysis; and it is therefore reasonable to conclude, that in order to make fine vermilion, it should be sufficient to effect the union of its elements at a high enough temperature, and to exclude the influence of all foreign matters; but, notwithstanding these discoveries, the art of making good vermilion is nearly as much a mystery as ever. M. Seguin, indeed, announced in his Memoirs, that he had succeeded in obtaining, in his laboratory, as good a cinnabar as that of Holland, and at a remunerative price; but whatever truth may be in this assertion, or however much the author may have been excited by the love of honour and profit, no manufacture on the great scale sprung up under his auspices. France is still as tributary as ever to foreign nations for this chemical product. At an exposition some years ago, indeed, a sample of good French vermilion was brought forward to prove that the problem was nearly solved; but that it is not so completely may be inferred from the silence on this subject in M. Dupin's report of the exposition, in 1834, where we saw so many chemical trifles honoured with eulogiums and medals by the judges of the show. The English vermilion is now most highly prized by the French manufacturers of sealing-wax.

M. Tuckert, apothecary of the Dutch court, published, long ago, in the *Annales de Chimie*, vol. iv., the best account we yet have of the manufacture of vermilion in Hol-

land; one which has been since verified by M. Payssé, who saw the process practised on the great scale with success.

"The establishment in which I saw, several times, the fabrication of sublimed sulphuret of mercury," says M. Tuckert, "was that of Mr. Brand, at Amsterdam, beyond the gate of Utrecht; it is one of the most considerable in Holland, producing annually, from three furnaces, by means of four workmen, 48,000 pounds of cinnabar, besides other mercurial preparations. The following process is pursued here:—

"The ethiops is first prepared by mixing together 150 pounds of sulphur with 1080 pounds of pure mercury, and exposing this mixture to a moderate heat in a flat polished iron pot, 1 foot deep, and 2½ feet in diameter. It never takes fire, provided the workman understands his business. The black sulphuret, thus prepared, is ground, to facilitate the filling with it of small earthen bottles capable of holding about 24 ounces of water; from 30 to 40 of which bottles are filled beforehand, to be ready when wanted.

"Three great subliming pots or vessels, made of very pure clay and sand, have been previously coated over with a proper lute, and allowed to dry slowly. These pots are set upon three furnaces bound with iron hoops, and they are covered with a kind of iron dome. The furnaces are constructed so that the flame may freely circulate and play upon the pots, over two-thirds of their height.

"The subliming vessels having been set in their places, a moderate fire is kindled in the evening, which is gradually augmented till the pots become red. A bottle of the black sulphuret is then poured into the first in the series, next into the second and third, in succession; but eventually, two, three, or even more, bottles may be emptied in at once; this circumstance depends on the stronger or weaker combustion of the sulphuret of mercury thus projected. After its introduction, the flame rises 4 and sometimes 6 feet high; when it has diminished a little, the vessels are covered with a plate of iron, a foot square, and an inch and half thick, made to fit perfectly close. In this manner, the whole materials which have been prepared are introduced, in the course of 34 hours, into the three pots; being for each pot, 360 pounds of mercury, and 50 of sulphur; in all, 410 pounds."

The degree of firing is judged of, from time to time, by lifting off the cover; for if the flame rise several feet above the mouth of the pot, the heat is too great; if it be hardly visible, the heat is too low. The proper criterion being a vigorous flame playing a few inches above the vessel. In the last of the 36 hours' process, the mass should be dexterously stirred up every 15 or 20 minutes, to quicken the sublimation. The subliming pots are then allowed to cool, and broken to pieces in order to collect all the vermilion encrusted within them; and which usually amounts to 400 lbs., being a loss of only 60 on each vessel. The lumps are to be ground along with water between horizontal stones, elutriated, passed through sieves, and dried. It is said that the rich tone of the Chinese vermilion may be imitated by adding to the materials for subliming one per cent. of sulphuret of antimony, and by digesting the ground article first in a solution of sulphuret of potassa, and, finally, in diluted muriatic acid.

The humid process of Kirchoff has of late years been so much improved, as to furnish a vermilion quite equal in brilliancy to the Chinese. The following process has been recommended. Mercury is triturated for several hours with sulphur, in the cold, till a perfect ethiops is formed; potash lye is then added, and the trituration is continued for some time. The mixture is now heated in iron vessels with constant stirring at first, but afterwards only from time to time. The temperature must be kept up as steadily as possible at 130° Fahr., adding fresh supplies of water as it evaporates. When the mixture which was black, becomes, at the end of some hours, brown-red, the greatest caution is requisite, to prevent the temperature from being raised above 114°, and to preserve the mixture quite liquid, while the compound of sulphur and mercury should always be pulverulent. The colour becomes red, and brightens in its hue, often with surprising rapidity. When the tint is nearly fine, the process should be continued at a gentler heat, during some hours. Finally, the vermilion is to be elutriated, in order to separate any particles of running mercury. The three ingredients should be very pure. The proportion of product varies with that of the constituents, as we see from the following results of experiments, in which 300 parts of mercury were always employed, and from 400 to 450 of water:—

| Sulphur. | Potash. | Vermillion obtained. |
|----------|---------|----------------------|
| 114 | 75 | 330 |
| 115 | 75 | 331 |
| 120 | 120 | 321 |
| 150 | 152 | 382 |
| 120 | 180 | 245 |
| 100 | 180 | 244 |
| 60 | 180 | 142 |

The first proportions are therefore the most advantageous; the last, which are those of M. Kirchoff himself, are not so good.

Brunner found that 300 parts of quicksilver, 114 of sulphur, 75 of caustic potassa, and from 400 to 450 of water, form very suitable proportions for the moist process; that the best temperature was 119° F.; and that 122° was the highest limit of heat compatible with the production of a fine colour.

The theory of this process is by no means clear. We may suppose that a sulphuret of potassium and mercury is first formed, which is eventually destroyed, in proportion as the oxygen of the air acts upon the sulphuret of potassium itself. There may also be produced some hyposulphite of mercury, which, under the same influence, would be transformed into sulphuret of mercury and sulphate of potash.

Sulphuret of potassium and mercury furnish also vermilion, but it is not beautiful. Red oxide of mercury, calomel, turbith mineral, and the soluble mercury of Hahnemann, treated with the sulphuret of potassium, or the hydrosulphuret of ammonia, are all capable of giving birth to vermilion by the humid way.

The vermilion of commerce is often adulterated with red lead, brickdust, dragon's blood, and realgar. The first two, not being volatile, remain when the vermilion is heated to its subliming point; the third gives a red tincture to alcohol; the fourth exhales its peculiar garlic smell with heat; and when calcined in a crucible with carbonate of soda, and nitre in excess, affords arsenic acid, which may be detected by the usual chemical tests.

VINEGAR. The gross revenue derived from vinegar manufactured in England in the year 1845, amounted to 284,317*l.* yielding a nett revenue of 57,182*l.* The gross revenue from vinegar manufactured in the United Kingdom, in the same year, amounted to 311,611*l.*, producing a nett revenue of 62,936*l.*

Vinegar; to detect sulphuric acid in. — Add a few drops of a concentrated solution of chloride of calcium, (muriate of lime) to the vinegar in question, not the least turbidness will ensue, even at a boiling heat. But if free, sulphuric acid be present in the vinegar, a very considerable turbidness will appear, followed by a precipitate of sulphate of lime. If the proportion of the sulphuric acid in the vinegar is larger than $\frac{1}{1000}$ part, the precipitate will appear even before it has become perfectly cold.

In addition to the article **ACETIC ACID**, I avail myself of this opportunity of describing the recent invention of *Anhydrous Acetic acid* as made by Mr. Gerhardt. It is obtained by mixing perfectly dry fused acetate of potash with about half its weight of chloride of benzoyle, and applying a gentle heat; when a liquid distils over, which, after being rectified, has a constant boiling point of 279° F., is heavier than water, with which it does not mix until after it has been agitated with it for some time. It dissolves at once in hot water, forming acetic acid.

Chlorbenzoyle, is prepared by transmitting dry chlore gas through pure oil of bitter almonds, till this at a boiling heat affords no more hydrochloric acid. The chlorbenzoyle is a limpid colourless fluid of 1.196 specific gravity. It has a peculiar, very penetrating smell, drawing tears from the eyes, as horseradish does. It has a high boiling point, and burns with a smoky flame. It dissolves sulphur and phosphorus with the aid of heat, and combines with sulphuret of carbon in all proportions.

Vinegar; new Method for manufacturing pure. — The decomposition of acetate of lime or lead by means of sulphuric acid has many inconveniences, and there is danger of the product being contaminated with sulphuric acid. Christl* was therefore induced to employ hydrochloric acid as a decomposing agent, and has found that when this acid is not used in excess, the distillate contains scarcely an appreciable trace of chlorine. A mixture of 100 lbs. of raw acetate of lime, obtained from the distillation of wood, and containing 90 per cent. of neutral acetate, with 120 lbs. of hydrochloric acid (20° Baumé) is allowed to stand during a night, and then distilled in a copper vessel. The application of heat requires to be gradual, in order to prevent the somewhat thick liquor from running over. The product of acetic acid amounted to 100 lbs. of 8° Baumé; it had a faint yellow colour and empyreumatic odour, which may be perfectly removed by treatment with wood-charcoal and subsequent rectification.

In order to obtain the acetate of lime sufficiently pure, Völckel† adopts the following process: — The raw pyrolignous acid is saturated with lime without previous distillation. A part of the resinous substances dissolved in the acid are thus separated in combination with lime. The solution of impure acetate of lime is either allowed to stand until it becomes clear or filtered ‡, then evaporated in an iron pan to about one half, and hydrochloric acid added until a drop of the cooled liquid distinctly reddens litmus-paper. The addition of acid serves to separate great part of the resin still held

* D'ingler's Polytech. Journ.

† Ann. der Chem. und Pharm.

‡ A part is distilled off in a copper still in order to obtain wood-spirit.

in solution, which collects together in the boiling liquid, and may be skimmed off, and likewise decomposes the compounds of lime with creosote, and some other imperfectly-known volatile substances, which are driven off by further evaporation. As these volatile substances have little or no action upon litmus-paper, its being reddened by the liquor is a sign that not only are the lime compounds of these substances decomposed, but also a small quantity of acetate of lime. The quantity of acid necessary for this purpose varies, and depends upon the nature of the pyrolignous acid, which is again dependent upon the quantity of water in the wood from which it is obtained. 150 litres of wood-liquor require from 4 to 6 lbs. of hydrochloric acid.

The solution of acetate of lime is evaporated to dryness, and a tolerably strong heat applied at last, in order to remove all volatile substances. Both operations may be performed in the same iron pans; but when the quantity of salt is large, the latter may be more advantageously effected upon cast-iron plates. The drying of the salt requires very great care, for the empyreumatic substances adhere very strongly to the acetate of lime, as well as to the compound of resin and acetic acid mixed with it, and when not perfectly separated, pass over with the acetic acid in the subsequent distillation with an acid, communicating to it a disagreeable odour. The drying must therefore be continued until upon cooling the acetate does not smell at all, or but very slightly. It then has a dirty brown colour. The acetic acid is obtained by distillation with hydrochloric acid in a still with a copper head and leaden condenser; when proper precautions are taken, the acetic acid does not contain a trace of either metal. The quantity of hydrochloric acid required cannot be exactly stated, because the acetate of lime is mixed with resin, and already formed chloride of calcium. In most instances 90 or 95 parts by weight of acid, 1.16 spec. grav., are sufficient to decompose completely 100 parts of the salt, without introducing much hydrochloric acid into the distillate.

The distilled acetic acid possesses only a very faint empyreumatic odour, very different from that of the raw pyrolignous acid; it is perfectly colourless, and should only become slightly turbid on the addition of nitrate of silver. If the acid has a yellowish colour, this is owing to resin having been spirited over in the distillation. It is therefore advisable to remove the resin, which is separated on the addition of hydrochloric acid, and floats upon the surface of the liquid, either by skimming or filtration through a linen cloth. The distilled acid has a specific gravity ranging between 1.058 and 1.061, containing upwards of 40 per cent. of anhydrous acetic acid. It is rarely that acid of this strength is required; and as the distillation is easier when the mixture is less concentrated, water may be added before or towards the end of the distillation. Vöckel recommends as convenient proportions —

100 parts of acetate of lime,
90 to 95 hydrochloric acid,
25 parts water,

which yield from 95 to 100 parts of acetic acid of 1.105 spec. grav.; 150 litres of raw pyrolignous acid yield about 60 lbs. of acetic acid of the above specific gravity.

The acid prepared in this way may be still further purified by adding a small quantity of carbonate of soda and redistilling; it is thus rendered quite free from chlorine, and any remaining trace of colour is likewise removed. The slight empyreumatic smell may be removed by distilling the acid with about 2 or 3 per cent. of acid chromate of potash. Oxide of manganese is less efficacious as a purifying agent.

Although pure acetic acid may be procured by the distillation of vinegar, the whole of the acid cannot be obtained except by distilling to dryness, by which means the extractive substances are burnt, and the distillate rendered impure. In order to obviate this difficulty, Stein* proposes to add 30 lbs. of salt to every 100 lbs. of vinegar; the boiling-point is thus raised, and the acid passes over completely.

By the quick process of HAM, when the fermentation is finished, the greatest care ought to be taken that all access of air is excluded from the wash, and that its temperature be reduced to, and maintained at a heat below the point where acetification commences. Those who, like Messrs. Evans, Hill, & Co., of Worcester, attach great importance to the fabrication of the best keeping vinegars are in the habit of filtering the fermented wash, and also of storing it away for many months in a cool situation ere it is passed through the acetifer; and there cannot be a moment's doubt concerning the great value of this practice, not only as regards the appearance and flavour of the resulting vinegar, but also in respect to its dietetic and sanitary properties.

All recently fermented wash contains a quantity of partially decomposed gluten, some of which is mechanically suspended merely, but by far the larger portion exists in a state of solution through the agency of carbonic acid gas.

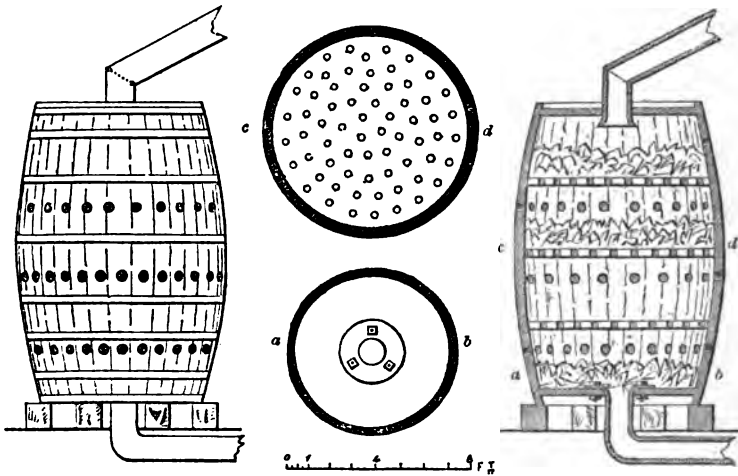
* Polytech. Centralblatt, 1852, p. 395.

A filter will remove the former, but time alone can dissipate the carbonic acid and lead to the deposition of the latter. At all events, time is the only available remedy, for though heat would expel the carbonic acid, yet it would at the same time drive off the alcohol; and agitation in contact with air, though it removed the carbonic acid, would tend to the formation of acetic acid, by which the gluten would be kept in solution more decidedly than before, and thus lead to the production of a turbid, ropy and impure vinegar, extremely liable to decompose and undergo the putrefactive fermentation. It is obvious therefore that the theoretical conditions needed in the treatment of fermented wort by the vinegar-maker are precisely those which we have shown to be in use at Worcester. That is to say, the gluten, when insoluble, should be removed by a filter, and when held in solution by carbonic acid, this must be slowly expelled by keeping at a temperature too low for acetification to take place, and which may be assumed at less than 55° Fabr. Fermented wort stored away at this temperature for six months will flow to the acetifier perfectly limpid and bright; it will cause no deposition of gluten upon the birch twigs, and thus secure complete oxidation; it will rapidly take on the grateful flavour of acetic ether, and never become tainted by the formation of that nauseous and noxious product aldehyde, which so frequently contaminates ill-made vinegar.

Presuming, however, that all the necessary precautions, with respect to care in washing, fermenting, and keeping the wort, have been attended to, we may now pass on to the acetifier, that is to say Ham's acetifier.

This is a wooden vat or vessel (see sketch) about 12 feet in height, and from 7 to 8

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feet in diameter, closed at top and bottom, except at the openings for the introduction of the wash and the exit of the vinegar. The sides are perforated by a few small holes for the admission of air, and within are three floors or partitions perforated with numerous holes for the passage of the wash through them. Upon these floors are laid bundles of birch twigs, to favour the dispersion and division of the fluid which passes through the acetifier, and is thus brought into the most intimate contact with the oxygen contained in the vessel, or admitted through the openings in its sides. The fluid or wash is of course admitted at the top of the acetifier, and suffered to trickle slowly through the masses of birch twigs and through the partitions, thus causing a rapid absorption of oxygen, and consequent production of vinegar, which with any undecomposed wash flows out at the bottom of the vessel, and is again pumped up to the top, and so on until the process is finished. If we examine the circumstances connected with the formation of vinegar in this way, we shall perceive at once, that it is a case of partial combustion, or, in other words, an example in which an organic compound is oxidized at a temperature and under conditions which prevent complete oxidation.

Every one must have observed that when common coals are thrown upon a fire, a part immediately bursts into flame, from which copious particles of soot or carbon are thrown off unburnt, though of the other constituent of the coal, that is to say, the hydrogen gas,

no particle escapes unoxidised. This arises from the fact that, except at very high temperatures, hydrogen has a greater affinity for oxygen than carbon has; consequently, as the supply of oxygen from the atmospheric air in the immediate neighbourhood is limited, the hydrogen seizes upon its equivalent to the exclusion of the carbon, which, therefore, remains and constitutes soot. Exactly in the same way the hydrogen of the alcohol in the wash oxidizes to the exclusion of the carbon, and vinegar is formed from the remaining or carbonaceous element, which becomes itself slightly oxidized. Thus 2 atoms of alcohol are composed of:—

| | | | | | | atoms. |
|----------|---|---|---|---|---|--------|
| Carbon | - | - | - | - | - | - 4 |
| Hydrogen | - | - | - | - | - | - 6 |
| Oxygen | - | - | - | - | - | - 2 |

whilst acetic acid or pure radical vinegar contains of—

| | | | | | | atoms. |
|----------|---|---|---|---|---|--------|
| Carbon | - | - | - | - | - | - 4 |
| Hydrogen | - | - | - | - | - | - 3 |
| Oxygen | - | - | - | - | - | - 3 |

If, therefore, we suppose the contact of air with alcohol to have led to the absorption of oxygen, so as to have oxidized three atoms of hydrogen, and thus produced three atoms of water, we have left

| | | | | | | atoms. |
|----------|---|---|---|---|---|--------|
| Carbon | - | - | - | - | - | - 4 |
| Hydrogen | - | - | - | - | - | - 3 |
| Oxygen | - | - | - | - | - | - 2 |

which, by the mere absorption of another atom of oxygen, becomes

| | | | | | | atoms. |
|----------|---|---|---|---|---|--------|
| Carbon | - | - | - | - | - | - 4 |
| Hydrogen | - | - | - | - | - | - 3 |
| Oxygen | - | - | - | - | - | - 3 |

or pure acetic acid, with which the water produced from the hydrogen remains in union and forms vinegar. From the above it follows, that as the oxidization of hydrogen generates heat or caloric, there ought to be a very appreciable rise in temperature during the passage of the wort through the acetifier. And, in practice, this is found to be the case; so that precautions are needed to prevent the heat from rising so high as to vaporise the remaining alcohol of the wash. The temperature sought to be obtained is about 90° or 92° Fahr., at which oxidation goes on freely, and the loss of alcohol is moderate. In using the word moderate, we speak practically rather than chemically; for in reality the loss is very serious with strong worts. From practical results, conducted with more than ordinary care, we have ascertained that about one-third of all the extractive matter of the malt and grain is lost or dissipated during the processes of fermentation and acetification. Thus, a wort having a specific gravity of 1.072, or, in technical language, weighing about 26 lbs. per barrel, afforded a vinegar containing 5.4 per cent. of pure acetic acid, and a residuary extract of 10 lbs. from 36 gallons. The former of these would indicate 35 lbs. of sugar, or 13.7 lbs. per barrel of gravity; whilst the latter shows 3.8 lbs. per barrel; the two united being only 17.5 lbs. instead of 26, the original weight. The loss, therefore, has been 8.5 lbs., or from a specific gravity of 1.072 to less than 1.050. This prodigious destruction of extract seems to imply that great improvements may yet take place in the manufacture of vinegar.

The manufacture of vinegar, by Ham's process, is an extremely interesting operation, and when conducted with proper care furnishes results of the most satisfactory and uniform character. These, however, are not to be obtained without a vast amount of experience and the most vigilant attention on the part of the manufacturer. Thus a difference in the water, in the malt, in the mode of washing, in the cooling of the wort or in the fermentation of the wort, will each give rise to modifications in the acetifying process which no subsequent skill or labour can afterwards rectify. There seems no doubt that the most important points in Ham's method are the cooling and fermentation of the wort, though, where perfection is sought for, no one of the other conditions can be omitted or neglected with impunity. We shall, therefore, proceed to treat of these conditions *seriatim*, rather than in the order of their importance. At first sight it might be supposed that the purer the water the better, that is to say, the less the amount of

earthy or saline constituents the more valuable the water would be for making vinegar. Experience, however, teaches us the contrary, and science confirms the truth of this teaching, by pointing out the real nature of the operation. When pure water is made to set at a high temperature upon the ordinary ingredients of a vinegar-maker's mash tun, it is not alone the sugar, gum, and starch of the grain which enters into solution, for under such circumstances the gluten is also dissolved. But this gluten is composed of vegetable albumen and vegetable gelatine, the former of which, as is well known, is capable of being decomposed and precipitated by many earthy and metallic salts, of which the sulphate of lime is one. If, therefore, this salt exists in the water employed for the fabrication of vinegar or of ale or beer, the wort will contain little or no vegetable albumen; consequently, the vinegar or beer made with such water never becomes cloudy or rosy, as happens when pure water is used, for these defects arise from an excess of albuminous matter. The water used for making the celebrated Burton ale contains a great deal of sulphate of lime, and the spring water of Worcester, which is employed by the extensive firm of Hill, Evans and Co., in that city, vinegar-makers, contains also a very large amount of sulphate of lime, and no doubt contributes much towards maintaining the well-established reputation of that firm. Whenever, therefore, much sulphate of lime exists in water, without the presence of any noxious ingredient, such water may always be relied upon as favourable for the production of good beer and vinegar.

As regards the malt, or rather the mixture of malt and grain, employed for the production of wort, the common Scotch distiller's formula is the best, containing, as it always does, a considerable per-centage of oats, for the long husk of the oat greatly facilitates the operation of draining, and thus secures the thorough separation of the wort from the spent grains.

In practice it is found necessary to ferment only two gravities, a high and a low, all the other qualities of vinegar being made by mixing or diluting these after acetification. The most common, and unquestionably the best, gravity for fermentation is that which in technical language weighs about 20 lbs., or has a specific gravity of 1.056; the other, or that intended for strong or proof vinegar, being of spec. grav. 1.072: this latter affords a vinegar containing about 5½ per cent of anhydrous acetic acid.

In every instance the fermentation must be carried to its utmost limit, or to zero at least, and in cooling the wort prior to fermentation, great care must be used to prevent the accession of the acetous fermentation before the yeast is added; for if this happens to any considerable extent, the nitrogenized matter of the yeast is then permanently retained in solution by the acetic acid, and this may give rise to the inconvenience called the "mother." To secure a perfect vinegar by Ham's process, as much attention is required, during the cooling and fermentation, as for the finest ale, and this axiom cannot be too strongly inculcated into the minds of vinegar-makers. The heat of the fermenting tun should not exceed 75° Fahr., as the alcohol formed by the process is apt at higher temperatures to pass off in considerable quantity with the carbonic acid, and thus give rise to a loss of vinegar. Presuming that the fermentation has been well conducted, and that the specific gravity of the wash is as low as water, or 1.000, the next step is to pass it through that apparatus which constitutes the great peculiarity of Ham's process. This apparatus is called the *aetifier*. See *Acetic Acid*.

VIOLET DYE, is produced by a mixture of red and blue colouring-matters, which are applied in succession. Silk is dyed a fugitive violet with either archil or brazil wood; but a fine fast violet, first by a crimson with cochineal, without tartar or tin mordant, and after washing, it is dipped in the indigo vat. A finish is sometimes given with archil. A violet is also given to silk, by passing it through a solution of verdigris, then through a bath of logwood, and, lastly, through alum water. A more beautiful violet may be communicated by passing the alumed silk through a bath of brazil wood, and after washing it in the river, through a bath of archil.

To produce violets on printed calicoes, a dilute acetate of iron is the mordant, and the dye is madder. The mordanted goods should be well dunged.

A good process for dyeing cottons violet, is—first, to gall, with 18 or 20 pounds of nut-galls for every 100 pounds of cotton; second, to pass the stuff, still hot, through a mordant composed of—alum, 10 pounds; iron-liquor, at 1½° B., and sulphate of copper, each 5 or 6 pounds; water, from 24 to 28 gallons; working it well, with alternate steeping, squeezing, airing, dipping, squeezing, and washing; third, to madder, with its own weight of the root; and fourth, to brighten with soap. If soda be used at the end, instead of soap, the colour called *prune de monsieur* will be produced; and by varying the doses of the ingredients, a variety of violet tints may be given.

The best violets are produced by dyeing yarn or cloth which has been prepared with oil as for the Turkey-red process. See *Madder*.

For the violet *pruneau*, a little nitrate of iron is mixed with the alum mordant, which

makes a black; but this is changed into *violet praseus*, by a madder-bath, followed by a brightening with soap.

VITRIFIABLE COLOURS; see ENAMELS, PASTES, POTTERY, and STAINED GLASS.
VITRIFIABLE PIGMENTS. The art of painting with vitrifiable pigments has not kept pace with the progress of science, and is far from having attained that degree of perfection of which it is capable. It still presents too many difficulties to prove a fertile field to the artist for his labours; and its products have, for this reason, never held that rank in art which is due to them from the indestructibility and brilliancy of the colours. The reason of this is attributable to the circumstance that the production of good vitrifiable pigments is mere chance work; and notwithstanding the numerous papers published on the subject, is still the secret of the few. The directions given in larger works and periodicals are very incomplete and indefinite; and even in the otherwise highly valuable *Traité des Arts Céramiques* of Brongniart, the chapter on the preparation of colours is far from satisfactory, and is certainly no frank communication of the experience gathered in the royal manufactory of Sèvres.

Now it is equally important to art and science that as many persons as possible should contribute to develop this art: but so long as every individual about to engage in the subject finds himself compelled, as I was on commencing, to discover the knowledge already acquired by others, but kept secret, the cost of time and trouble requisite is sufficient to frighten most persons, and, what is of greatest injury to the art, especially the scientific chemist, from working on the subject.

The branch of painting with vitrifiable pigments which has acquired its greatest development is the art of painting on porcelain. The glaze of hard felspar porcelain, owing to its difficult fusion, produces less alteration upon the tone of a colour of the easily fusible pigments than is the case in painting upon glass, enamel, fayence, &c. The colours for painting upon porcelain are all of them, after the firing, coloured lead-glasses throughout; but before this operation, most of them are mere mixtures of colourless lead-glass, the *flux*, and a pigment. In the so-called gold colours, purple, violet and pink, the pigments are preparations of gold, the production of which has hitherto been considered as especially difficult and uncertain. The following are the processes which I employ:—

Light Purple.—5 grammes of tin turnings are dissolved in boiling nitromuriatic acid, the solution concentrated in the water bath until it solidifies on cooling. The perchloride of tin prepared in this manner, and which still contains a slight excess of muriatic acid, is dissolved in a little distilled water, and mixed with 2 grammes of solution of protochloride of tin of 1·700 sp. gr., obtained by boiling tin turnings in excess with muriatic acid to the required degree of concentration. This mixed solution of tin is poured into a glass vessel, and gradually mixed with 10 litres of distilled water. It must still contain just so much acid that no turbidness results from the separation of oxide of tin; this may be ascertained previously by taking a drop of the concentrated solution of tin upon a glass rod, and mixing it in a watch glass with distilled water. A clear solution of 0·5 grammes gold in nitromuriatic acid, which must be as neutral as possible, is poured into the solution of tin diluted with 10 litres of water, constantly agitating the whole time. The gold solution should have been previously evaporated nearly to dryness in the water bath, then diluted with water, and filtered in the dark.

On adding the gold solution, the whole liquid acquires a deep red colour, without, however, any precipitate being formed; this instantly separates upon the addition of 50 grammes of solution of ammonia. But if no precipitate should result, which may happen if the amount of ammonia was too great in proportion to the acid contained in the liquid, and in which case the liquid forms a deep red solution, the precipitate immediately results upon the addition of a few drops of concentrated sulphuric acid. It subsides very quickly. The supernatant liquid should be poured off from it as soon as possible, and replaced 5 or 6 times successively by an equal quantity of fresh spring water. When the precipitate has been thus sufficiently washed, it is collected upon a filter: and as soon as the water has drained off completely, removed while still moist with a silver spatula, and mixed intimately upon a ground plate of a glass by means of a spatula and grinder with 20 grammes of lead-glass, previously ground very fine upon the same plate with water. The lead-glass is obtained by fusing together 2 parts of minium with 1 part of quartz sand and 1 part of calcined borax.

The intimate mixture of gold-purple and lead-glass is slowly dried upon the same glass plate upon which it had been mixed in a moderately warm room, carefully protected from dust, and when dry, rubbed to a fine powder, and mixed with three grammes of carbonate of silver.

In this manner we obtain 33 grammes of light purple pigments from 0·5 gramme gold.

The above proportion of lead-glass and carbonate of silver to the gold precipitate holds

good only for a certain temperature, at which the colour must be burnt-in upon the porcelain, and which is situated very near the fusing point of silver.

To obtain the colour with a less degree of heat, the amount of lead-glass added to the gold must be greater, but that of the carbonate of silver less. The same holds good with respect to the preparation of the purple pigment for glass painting.

The best purple may be spoiled in the baking in the muffle. When this is done at too low a temperature, the colour remains brown and dull; but if the right degree of temperature has been exceeded, it appears pale and bluish. Reducing, and especially acid, vapours, vapours of oxide of bismuth, &c., have likewise an injurious effect upon it.

Dark purple. — The clear and neutral solution of 0.5 gramme gold in nitromuriatic acid is diluted in a glass vessel with 10 litres of distilled water, and mixed under constant agitation with 7.5 grammes of the solution of protochloride of tin of 1.700 sp. gr. prepared in the manner described above. The liquid is coloured of a dark brownish-red; but the precipitate is only deposited on the addition of a few drops of concentrated sulphuric acid. The supernatant liquid is poured off, and replaced five or six times successively with an equal amount of spring water. The precipitate, which is sufficiently washed, is collected on a filter; and after the excess of water is drained off, removed while still moist with a spatula, and mixed, exactly as described for the light purple, upon a glass plate with 10 grammes of the above lead-glass, dried, then reduced to a fine powder, and mixed with 0.5 grammes carbonate of silver; it furnishes about 19 grammes of dark purple pigment. The stated proportion of lead-glass and carbonate of silver to the gold is for the same temperature of firing as given for the mixture of light purple; for a lower temperature, and also for painting upon glass, the quantity of lead-glass must be increased and that of the silver salt diminished.

Red Violet. — The gold precipitate from 0.5 gramme gold is prepared in the same manner as for the dark purple, and whilst moist taken from the filter, and mixed intimately upon the plate of glass with 12 grammes of a lead glass prepared by fusing 4 parts of minium with 2 parts of quartz sand and 1 part calcined borax; it is then dried as above, and reduced to a fine powder upon a plate of glass, but without any addition of silver. The proportion of lead-glass to gold applies likewise for the same degree of temperature as in the case of the light and dark purple pigments; a lower temperature requires a larger proportion of lead glass. A slight addition of silver to this pigment converts the red violet into a dark purple; and when employed alone for painting upon glass, it gives a very excellent purple.

Blue Violet. — This same gold precipitate of 0.5 grammes gold is mixed, while still moist, upon the glass plate with 10.5 grammes of a lead glass, obtained by fusing 4 parts of minium with 1 of quartz sand, drying it slowly in the manner above mentioned, and then reducing it to a fine powder upon the glass plate. When the pigment is burnt-in at a lower temperature, a larger addition of lead-glass is required. This blue violet pigment is more especially adapted for mixing with blue pigments. It is not applicable to glass painting. The most important requisite in the preparation of good purple and violet vitrifiable pigment is the very minute state of division of the gold in the gold precipitate, and of the latter in the lead-glass, which is accomplished by mixing the moist precipitate with the glass.

By mixing the light purple with the dark purple or with the red violet, or the red violet with the dark purple, in different proportions, the artist is able to produce every possible tint of purple and violet. The light purple, without any additional silver, furnishes an amaranth-red colour, like that seen upon most of the porcelains of the preceding century, when the peculiar property of silver, of converting the amaranth-red into a rose-red colour, does not appear to have been known. Dr. Richter, who at the commencement of this century prepared the pigments for the Royal Berlin manufactory of porcelain, appears, however, to have employed it for his purple, as a very beautiful rose colour may be seen upon the painted porcelain of that time.

Pink. — One gramme of gold is dissolved in nitromuriatic acid; the solution mixed with one of 50 grammes of alum in 20 litres of spring water; then mixed, constantly agitating, with 1.5 gramme solution of protochloride of tin of 1.700 specific gravity, and so much ammonia added until all the alumina is precipitated. When the precipitate has subsided, the supernatant liquid is poured off, and replaced about 10 times successively by an equal amount of fresh spring water; the precipitate is then collected on a filter, and dried at a gentle heat. It weighs about 19.5 grammes; and to prepare the pigment is mixed with 2.5 grammes carbonate of silver, and 70 grammes of the same lead-glass, described under light purple, (2 minium, 1 quartz sand, 1 calcined borax), and reduced to a fine powder on the glass plate.

This colour is adapted only for the production of a light pink ground upon porcelain, and must only be applied in a thin layer; when laid on in a thick layer, the gold separates in a metallic state, and no colour is produced.

All the gold colours above described do not furnish, when fused alone in a crucible,

red or violet glasses, as might be expected; but dirty brown or yellowish glasses, which appear troubled from the separation of metallic gold and silver; this peculiar beautiful tint is only developed when they are fused upon the porcelain glass in a layer, which must not be too thick; they then colour it through and through, as a piece of porcelain painted with it shows distinctly in the fracture. If the layer exceeds a certain thickness, the gold and silver separate in a metallic state; and they produce either a liver colour, as for instance the purple and violet pigments, or no colour at all, as is the case with the more fusible pink pigment.

Yellow Pigments for painting upon Porcelain.—The yellow vitrifiable pigments are lead-glasses, coloured either by antimoniac acid or oxide of uranium. The antimoniate of potash is prepared by igniting 1 part of finely powdered metallic antimony with 2 parts of nitre, in a red-hot Hessian crucible, and washing the residue with water. The oxide of uranium is obtained in the fittest state, by heating the nitrate, until the whole of the nitric acid is expelled.

Lemon Yellow.—8 parts antimoniate of potash, $2\frac{1}{2}$ parts oxide of zinc, 36 parts of lead-glass, (prepared by fusing together 5 parts minium, 2 parts of white sand, and 1 part of calcined borax), are intimately mixed, and beaten to redness in a porcelain crucible, which is placed in a Hessian crucible, until the mixture forms a paste; it is then taken out with a spatula, pounded after cooling, and ground upon a plate glass. If the pigment is fused longer than requisite for the perfect union of the ingredients, the yellow colour is converted into a dirty gray by the destruction of the antimoniate of lead.

Light Yellow.—4 parts antimoniate of potash, 1 part oxide of zinc, and 36 parts of lead-glass, (prepared by fusing together 8 parts of minium and 1 part of white sand), are well mixed, fused in a Hessian crucible, and after cooling, pounded and ground. In the preparation of this colour, long fusion is less injurious than with the preceding one, owing to the absence of the borate of soda in the lead-glass. The colour itself is more intensely yellow than the preceding one, and is extremely well adapted for mixing with red and brown pigments; but it does not furnish such pure tints as that when mixed with green; owing to its higher specific gravity, it flows more freely from the brush, and may be laid on in a thicker layer, without scaling off after the firing.

Dark Yellow, 1.—48 parts minium, 16 parts sand, 8 calcined borax, 16 antimoniate of potash, 4 oxide of zinc, and 5 parts peroxide of iron (*caput mortuum*), are intimately mixed and fused in a Hessian crucible, until the ingredients have perfectly combined, but no longer; otherwise, the golden yellow colour is converted into a dirty gray, as in the case of the lemon-yellow pigment.

Dark Yellow, 2.—20 parts minium, $2\frac{1}{2}$ white sand, $4\frac{1}{2}$ antimoniate of potash, 1 part peroxide of iron (*caput mortuum*), and 1 part oxide of zinc, are well mixed and fused in a Hessian crucible. Long fusion is less injurious in this case than in the preceding. Iron-red pigment may be laid on and near this dark yellow 2, without its being destroyed, or the harmony of the tints injuriously affected.

For landscape and figure painting, the above-mentioned yellow pigments should be made less readily fusible, in order to paint with them upon or beneath other colours, without any fear of what has been painted being dissolved by the subjacent or superposed pigment. This property is given to it by the addition of Naples yellow, which is best prepared for this purpose by long continued ignition of a mixture of 1 part tartar-emetic, 2 parts nitrate of lead, 4 parts of dry chloride of sodium, in a Hessian crucible, and washing the pounded residue with water. Very useful yellow colours are likewise obtained by mixing this Naples yellow with lead-glass; they are, however, more expensive than those above given. A very excellent yellow for landscape painting may be prepared, for instance, by mixing 8 parts Naples yellow and 6 parts lead-glass, (obtained by fusing 2 parts of minium with 1 of white sand and 1 of calcined borax).

The yellow pigments obtained with antimony, after being burnt-in upon the porcelain, appear under the microscope to be mixtures of a yellow transparent substance (antimoniate of lead?), and a colourless glass, and not homogeneous yellow glasses.

Uranium Yellow.—1 part oxide of uranium, 4 parts lead-glass, (prepared by fusing 8 parts minium with 1 part white sand), are intimately mixed and ground upon a glass plate. This colour is not adapted for mixing with others, with which it produces discordant tints. It may be shaded with dark purple or violet.

Uranium Orange.—2 parts oxide of uranium, 1 part chloride of silver, and 3 parts bismuth glass, (prepared by fusing 4 parts of oxide of bismuth with 1 part of crystallized boracic acid), are intimately mixed and ground upon a plate glass. This orange is not adapted, any more than the yellow pigment, for being mixed with other colours. When examined under the microscope, after being burnt-in upon porcelain, the uranium pigments appear as pale yellow-coloured glasses, in which unaltered oxide

of uranium is suspended. Only a small portion, therefore, dissolved in the fusing.

Green Pigments for painting upon Porcelain. *Blue Green* of protoxide of mercury and 1 part of chemically pure oxide of zinc, in order to produce as intimate a mixture then heated in a porcelain tube, open at both ends, until expelled. The beautiful bluish-green powder thus obtained is ground upon the glass plate, and the lid cemented to it with a porcelain crucible, and the lid cemented to it with a porcelain crucible carefully broken after the cooling, and the pigments remove a small quantity of chromate of potash. In this way a mixture of chromium and oxide of cobalt is obtained in nearly equal proportions, which possesses the bluish-green colour of verdigris.

The blue-green pigment consists of a mixture of 1 part of oxide of chromium and oxide of cobalt, $\frac{1}{2}$ part of oxide of zinc (prepared by fusing together 2 parts minium, 1 part white borax), which are mixed and ground upon the glass plate with lemon-yellow, any desired intermediate tint may be given to 6 parts of lemon-yellow furnishes a beautiful green.

Dark Green.—The chromate of mercury is treated with the mixture of it with oxide of cobalt for the blue-green green oxide of chromium thus obtained is mixed with 3 parts of white borax under blue-green, and ground upon the glass plate.

Green for shading.—8 parts chromate of mercury are intimately mixed, and exposed in a shallow dish to the steam furnace, during one of the bakings. In this manner, a mixture of oxide of cobalt is obtained, of a greenish-black colour, the weight of the lead-glass directed for the blue-green blackish-green colour, for shading other green colours.

When thin splinters of the green pigments of chromium are examined under the microscope, it is distinctly seen that chromium, or of the oxide of chromium and cobalt, are colourless lead-glass.

Blue Pigments for painting upon Porcelain. *Dark Blue* oxide of cobalt, 1 part oxide of zinc, 1 part lead-glass, 2 parts of minium and 1 of white sand), are well mixed in a porcelain crucible, for at least 3 hours, at a red heat; then poured and ground upon the glass. When this pigment cools slowly it forms acicular crystals. Long-continued fusion, at not too high a temperature to obtain a beautiful tint; this is best attained by fusing in the second floor of the porcelain furnace; this is also the best fusing the lead-glasses.

Light Blue.—1 part oxide of cobalt, 2 parts oxide of zinc (prepared by fusing together 2 parts of minium and 1 of white borax), lead-glass, (prepared by fusing together 2 parts of minium and 1 of white borax); are well mixed and fused, as directed for the dark blue.

Blue for shading.—10 parts oxide of cobalt, 9 parts of white borax, (obtained by fusing 2 parts of minium and 1 of white borax), lead-glass, (prepared by fusing together 2 parts of minium and 1 of white borax), are mixed and fused, as directed for the dark blue colour is only used for shading, or to be applied upon, or mixed with other blue pigments, for which purpose it is admirably suited.

Sky Blue.—2 parts of dark blue, 1 part oxide of zinc (prepared by fusing 4 parts minium with 1 of white borax), ground upon the glass plate. This pigment is employed for shading other colours, only for painting the sky in landscape.

The blue pigments described likewise appear under the microscope when burnt-in upon the porcelain, not to be homogeneous of a transparent blue substance, (silicate of cobalt and zinc).

Turquoise Blue.—3 parts of chemically pure oxide of zinc, are dissolved together in sulphuric acid, 40 parts ammonia-alum added, the mixed solutions are filtered, and the residue heated to expel the whole of the water; then re-dissolved in a crucible to an intense red heat for several hours. When it has been exposed, during one firing, to the heat of a steam furnace, it is a combination of nearly 4 equivalents alumina, 3 equivalents

oxide of zinc, and is of a beautiful turquoise-blue colour. When the oxides are mixed in other proportions than those above given, they do not furnish such beautiful coloured compounds. To impart to it a slightly greenish tint, a little moist recently precipitated protochromate of mercury is mixed with the above described solution of ammoniac-alum, zinc, and cobalt; with the above quantities, $\frac{1}{4}$ part of the chromate, calculated in the dry state, suffices.

The turquoise-blue vitrifiable pigment is prepared by mixing 1 part of the compound of alumina-oxide of zinc and cobalt with two parts of bismuth glass (prepared by fusing 5 parts of oxide of bismuth with 1 part of crystallized boracic acid).

The receipt for the preparation of the turquoise-blue pigment, communicated in the *Traité des Arts Chimiques* by Brongniart, is incorrect; for a lead-glass of the composition there given (3 parts minium, 1 part sand, 1 part boracic acid) destroys the turquoise blue pigment entirely on fusion, and only a dirty bluish gray colour is produced. On examining under the microscope the turquoise blue pigment burnt-in upon porcelain, it appears to be a mixture of a transparent blue substance and a colourless glass. The transparent blue substance in all probability is the above described compound of oxide of cobalt and alumina, which is of itself transparent under the microscope, but the transparency of which is increased by the surrounding fused glass of bismuth, just like the fibres of paper by oil. This is probably the case also with the microscopic blue constituent of the other blue vitrifiable pigments, and which is probably silicate of zinc and cobalt; for this, when prepared separately, forms a pure blue transparent powder.

Black and Gray Colours for painting upon Porcelain.—Iridium Black.—Iridium, as obtained in commerce from Russia in the state of a fine gray powder, is mixed with an equal weight of calcined chloride of sodium, and heated to a faint red in a porcelain tube, through which a current of chlorine is passed. In this manner a portion of the iridium is converted into the bichloride of iridium and sodium, which is dissolved out with water from the ignited mass. The aqueous solution of the double salt is evaporated to dryness with carbonate of soda, and then extracted with water, which furnishes black sesquioxide of iridium. This is dried and mixed with twice its weight of lead-glass (prepared by fusing together 12 parts of minium, 3 parts of white sand, and 1 part of calcined borax), and ground upon a plate of glass. The iridium, which remained undecomposed in the first treatment with sea-salt and chlorine, is again submitted to the same treatment.

Iridium Gray.—1 part of the sesquioxide of iridium, 4 parts of oxide of zinc and 32 parts of lead glass (prepared by fusing together 5 parts of minium, 2 parts of sand and 1 part of calcined borax) are intimately mixed and ground fine upon a plate of glass. On microscopical examination of the iridium pigments after they have been burnt-in upon porcelain, the sesquioxide of iridium is seen to be suspended in the transparent fused lead-glass. It is owing to the unalterability of the sesquioxide of iridium that it admits of being mixed with all other vitrifiable colours without injuriously affecting the tints, as is the case with all the other vitrifiable gray and black pigments.

Black from Cobalt and Manganese.—2 parts of sulphate of cobalt deprived of its water of crystallization, 2 parts of dry protosulphate of manganese, and 5 parts of nitre, are intimately mixed, and heated to redness in a Hessian crucible until the whole of the nitre is decomposed. The calcined mass, exhausted with boiling water, furnishes a deep black powder, which consists of a combination of oxide of cobalt and oxide of manganese. 1 part of this compound is mixed with $2\frac{1}{2}$ parts of lead-glass (prepared by fusing together 5 parts of minium, 2 parts of sand and 1 part calcined borax), and ground fine upon a plate of glass.

Gray from Cobalt and Manganese.—2 parts of the above compound of the oxide of cobalt and manganese, 1 part oxide of zinc, and 9 parts of lead-glass (prepared by fusing together 5 parts of minium, 2 parts of sand, and 1 part of calcined borax) are mixed and ground fine.

These black and gray pigments are far less expensive to prepare than those from iridium, and are not inferior to them in colour; but they do not mix so well with other colours, and when baked several times they vary their tint somewhat, which renders their application less certain. When these colours burnt-in upon porcelain are examined under the microscope, it is seen that the oxide of cobalt and manganese is not dissolved by the lead-glass, but merely suspended in it.

Besides these colours a very infusible black is used in painting, which is not acted upon by the superposed colours in the fusion; it is the

Ground Black, which consists of 5 parts of blue violet (gold purple), $1\frac{1}{2}$ part of oxide of manganese and cobalt, and $1\frac{1}{2}$ part of oxide of zinc; these are intimately mixed and ground fine upon a plate of glass.

White for covering.—1 part minium, 1 part white sand, and 1 part crystallized boracic acid, are well mixed, and fused in a porcelain crucible. This white enamel has the peculiarity of forming a colourless clear glass when quickly cooled, for instance, when poured into water; while, when slowly cooled, it remains perfectly white and opaque. On heat-

ing the clear glass to its melting point, it loses its transparency, and becomes opaque as before. This property it possesses in common with the enamels, the opacity of which is produced by arsenic or tungstic acid; probably the opacity in the present case is produced by the separation of silicate of lead, as in the white enamels by arseniate or tungstate of potash or by oxide of zinc. It is, however, of excessive minuteness; for under the microscope, even with the highest power, the glass merely exhibits a yellowish turbidness, and no individual particles are visible.

This white serves for marking the lightest part of the pictures, where it is impossible to produce them by exposing the bare surface of the white porcelain; it is also frequently mixed in small quantity with the yellow and green pigments, to make them cover well.

Lead Flux.—A colourless lead-glass for touching-up those parts of the painting which have remained dull, and for mixing with those pigments which are not easy of fusion, is obtained by mixing together 5 parts of minium, 2 parts of white sand, and 1 part of calcined borax.

Red and Brown vitrifiable Pigments derived from Peroxide of Iron for painting upon Porcelain.—**Yellow Red.**—Anhydrous sulphate of the peroxide of iron is heated to redness on a dish in an open muffle, and constantly stirred with an iron spatula until the greater portion of the sulphuric acid has been expelled, and a sample mixed with water upon a glass-plate exhibits a beautiful yellowish-red colour; after cooling, the peroxide of iron is freed by washing with water from any undecomposed sulphate, and dried. To prepare the pigment, 7 parts of the yellowish-red peroxide of iron are well mixed with 24 parts of lead-glass (prepared by fusing together 12 parts of minium, 3 parts of sand, and 1 part of calcined borax), and ground fine upon a plate of glass.

Brown Red.—When the persulphate of iron is heated to redness until the whole of the sulphuric acid is expelled, and a sample exhibits a dark red colour, the peroxide of iron is well suited for a brownish red pigment, which is prepared in the same manner as directed for the yellowish red.

Bluish Red (Pompadour).—When the persulphate is heated still more strongly, it is deprived of its loose consistence, becomes heavier, and acquires a bluish red colour. To hit this point exactly when the oxide of iron has assumed the desired carmine tint is not so easy, as it changes very rapidly at these temperatures.

The pigment is prepared by mixing 2 parts of the purple coloured peroxide of iron with 5 parts of lead-glass, obtained by fusing together 5 parts of minium, 2 parts of sand and 1 part of calcined borax.

Chesnut Brown.—This colour of various shades, even to black, is acquired by the peroxide of iron, at still higher degrees of heat than required for the preparation of red colours; the pigments are prepared by mixing 2 parts of the chesnut-brown peroxide of iron with 5 parts of lead glass, prepared by fusing together 12 parts of minium, 3 parts of sand, and 1 part of calcined borax.

Chamois.—1 part of the hydrate of the peroxide of iron, prepared by precipitating the peroxide of iron with ammonia, is mixed with 4 parts of the lead-glass, described in the preceding, and the mixture ground fine on a plate of glass. This colour is laid on very thin, and serves to produce a yellowish brown ground.

Flash colour.—1 part red peroxide of iron, 4 parts of dark yellow 2., and 10 parts of lead-glass, prepared as described under chesnut-brown, are well mixed and ground fine upon a plate of glass. This colour can also only be employed in a thin layer. Various tints may be given to it by mixing it with a red peroxide of iron, sky-blue or dark yellow 2. The red of the cheeks and lips are painted upon it with Pompadour red.

When the above colours are burnt-in upon porcelain, it is distinctly seen under the microscope that the peroxide of iron is suspended unaltered in the clear lead-glass; at least the quantity dissolved by the fused lead-glass is so small that it is not perceptibly coloured.

Various Brown Pigments for painting upon Porcelain.—**Light Brown 1.**—6 parts of dry protosulphate of iron, 4 parts of dry sulphate of zinc, and 13 parts of nitre are well mixed, and heated to redness in a Hessian crucible, until the whole of the nitre is decomposed. When cold, the crucible is broken, the residue removed, and separated by boiling with water from soluble matters. A yellowish brown powder remains, which is a combination of oxide of zinc with peroxide of iron. The pigment is made by mixing 2 parts of this compound with 5 parts of lead-glass, prepared by fusing together 12 parts of minium, 3 parts of sand, and 1 part of calcined borax.

Light Brown 2.—2 parts of dry sulphate of iron, 2 parts of dry sulphate of zinc, and 5 parts of nitre, are treated in the same manner as described for light brown, 1. The resulting compound of oxide of zinc and iron is of a lighter tint; the pigment is prepared from it as above.

Light Brown, 3.—1 part of dry sulphate of iron, 2 parts of dry sulphate of zinc, and 4 parts of nitre are treated as directed for 1. and 2.

The light brown colours, after having been burnt-in upon porcelain, exhibited under the microscope the transparent particles of the yellowish oxide of iron and zinc suspended in the colourless lead-glass.

Bistre Brown, 1.—1 part dry sulphate of manganese, 8 parts of dry sulphate of zinc, 13 parts dry sulphate of iron, and 26 parts nitre, are treated as directed for light brown, 1, and the resulting dark brown powder (a combination of the oxides of zinc, iron, and manganese), mixed with $2\frac{1}{2}$ times its weight of lead-glass of the same composition as for light brown, 1.

Bistre Brown, 2.—1 part dry sulphate of manganese, 4 parts dry sulphate of iron, 4 parts dry sulphate of zinc, 12 parts nitre, are treated as for bistre brown, 1. The colour is somewhat darker.

Sepia Brown, 1.—1 part dry sulphate of iron, 1 part dry sulphate of manganese, 2 parts dry sulphate of zinc, and 5 parts nitre, are treated as directed for light brown, 1, and the grayish brown pigment thus obtained mixed with $2\frac{1}{2}$ times its weight of lead-glass of the above composition.

Sepia Brown, 2.—1 part calcined sulphate of iron, 2 parts calcined sulphate of manganese, 6 parts calcined sulphate of zinc, and 10 parts nitre, are treated as for sepia, 1.

Dark Brown.—1 part dry sulphate of cobalt, 4 parts dry sulphate of zinc, 4 parts dry sulphate of iron, and 10 parts of nitre, are mixed and treated as directed for light brown, 1. The resulting beautiful dark reddish brown combination of the oxides of cobalt, zinc, and iron is mixed with $2\frac{1}{2}$ times its weight of the same lead-glass as for the preceding colours.

Chrome Brown.—1 part of hydrated peroxide of iron is intimately mixed with 8 parts of the chromate of the protoxide of mercury, and then heated to redness in a dish, in an open muffle, to expel the whole of the mercury. The dark reddish brown compound of the oxides of chromium and iron is mixed with 3 times its weight of lead glass, prepared by fusing together 5 parts of minium, 2 parts of sand, and 1 part of calcined borax.

When examined under the microscope, after being burnt-in upon porcelain, these different brown colours also show that the dark compounds are merely suspended in the lead-glass, and not, or merely to a small extent, dissolved. The direction above given for preparing the coloured combinations of the oxides in the dry way, for the bodies which constitute the different brown pigments, is cheaper and more certain than the precipitation of the mixed solutions by carbonate of soda and calcination of the washed precipitate, which also answers. If, however, the several oxides were to be mixed with the lead-glass separately, instead of combined, the colours would not be pure, that is to say they would exhibit after the firing different tints in a thick and thin layer; they would moreover possess a totally different colour before the burning from that which they acquire after that operation, and would thus contribute to deceive the artist.

Gold purple is obtained, according to the process of Ladersdorff, by mixing a solution of 1 part ducat gold, in 4 parts *aqua regia*, with 1 drachm of tin salt dissolved in 4 ozs. distilled water, and a solution of 1 drachm of gum in 8 ozs. of water in the following proportions:—

| | | | | | |
|------------------------|---|---|---|---|---------|
| Distilled water | - | - | - | - | 3 ozs. |
| Solution of gum-arabic | - | - | - | - | 26 grs. |
| do of tin salt | - | - | - | - | 14 " |
| do of gold | - | - | - | - | 23 " |

and adding alcohol of 0.863 spec. grav., until the liquid begins to grow turbid. The purple is deposited and washed with spirit of 0.953. The dried precipitate has a brownish colour, and furnishes, when all the gum has been carefully removed by washing, a very beautiful purple after the firing.

According to Fuchs, 1 oz. *liq. ferri muriat. oxydati*, Ph. bor., is mixed with 3 ozs. of distilled water, and a solution of 1 oz. protochloride of tin in 6 ozs. distilled water, and 10 drops of muriatic acid added until the whole has acquired a greenish colour, when a further addition of 16 ozs. of distilled water is made.

On the other hand, some ducat gold is heated to boiling with pure nitric acid until all the gold is dissolved. An excess of acid should be avoided. 360 parts of distilled water are added to this solution of gold; and then the above solution of iron and tin gradually poured into it until the whole of the purple is precipitated. This precipitate has likewise a brownish tint after drying, but furnishes a beautiful purple after burning.

It has been found, however, that gold purple prepared according to the following process is preferable, especially as regards the external appearance. A mixture of 4 parts pure nitric acid of 1.24 spec. grav., and 1 part pure muriatic acid, which is mixed with half as much pure alcohol of 0.863, and chemically pure tin, gradually added in

small portions until no more is dissolved; the solution must be effected slowly, on which account the vessel containing the mixture should be placed in snow or cold water. The carefully decanted solution is diluted with 80 times its weight of distilled water, and mixed with a solution of gold, prepared according to the above directions. The precipitate is purple-red, and remains so after drying. The tin solution for this purpose cannot be preserved long, otherwise nitric-ether is formed; and the higher oxidation of the tin salt no longer furnishes such beautiful precipitates with gold as the recently prepared solution.

For mixing with the purple in order to produce a rose colour, the author does not employ carbonate of silver, but the metal in a very minute state of division, obtained by mixing the finest silver leaf with honey and a few drops of ether, and well grinding it, when the honey is washed out with water. Mr. Waechter uses as a flux for the purple colours a lead-glass, consisting of 6 parts minium, 2 parts silica, and 2 parts calcined borax.

With respect to the chrome colours, he observes, that the expensive method for their preparation by means of the chromate of the protoxide of mercury is still the only one by means of which a fine colour can be obtained.

Cobalt Colours.—In purifying the cobalt for porcelain colours, the removal of the whole of the arsenic is of less consequence than that of the iron. Cobalt ores from various localities, Tunaberg, Saxony, and Thuringia, are treated in the following manner. The mineral is reduced to a fine powder in an iron mortar, kept for the purpose, and mixed with $\frac{1}{2}$ its weight of charcoal powder; then exposed in Hessian crucibles to a red heat under a chimney with a good draught or in the open air, and roasted as long as arsenical vapours escape, a very disagreeable operation, which lasts several hours. The ore thus prepared is now boiled over the fire with a mixture of 4 parts nitre, and 1 part muriatic acid, 1 part of which is diluted with 3 parts of water. This operation is repeated about 3 times, with less acid. The liquids are allowed to settle, the clear portion decanted, the remainder diluted with water and filtered, and the solution evaporated to dryness. The dry mass is mixed with some water, heated, and separated by filtration from the residue of arseniate of iron. The green liquid, which now contains more or less cobalt, iron, nickel, and manganese, is mixed with a filtered solution of pearlsh, until the dirty reddish precipitate begins to turn blue. Care and experience in this operation are requisite, otherwise a loss of cobalt might result. The precipitate of arseniate and carbonate of iron, which at the same time contains nickel and manganese, is separated by filtration, and the beautiful red liquid mixed with more of the solution of pearlsh until the whole of the cobalt is precipitated; the precipitate is carefully washed and dried. This hydrated oxide of cobalt is sufficiently pure for technical purposes, and answers just as well as that prepared from oxalate of cobalt or by caustic ammonia.

For painting, the oxide of cobalt is heated in a Hessian crucible with 1 part silica, and $1\frac{1}{2}$ part oxide of zinc for two hours in a blast furnace, then reduced to a fine powder in a porcelain mortar, and mixed with an equal weight of lead-glass.

Yellow colour.—A beautiful yellow is obtained from 2 oz. minium, $\frac{1}{2}$ oz. *Stib. oxydat. alb. abl.*, 2 drms. oxide of zinc, 2 drms. 2 scruples calcined borax, $\frac{1}{2}$ oz. silica, $\frac{1}{2}$ drn. dry carbonate of soda, and 1 scruple *ferr. oxydat. fuscum*, which are well mixed, fused in a crucible, and then ground fine.—*Waechter.*

VITRIOL, from *vitrum*, glass, is the old chemical, and still the vulgar appellation of sulphuric acid, and of many of its compounds, which in certain states have a glassy appearance: thus—

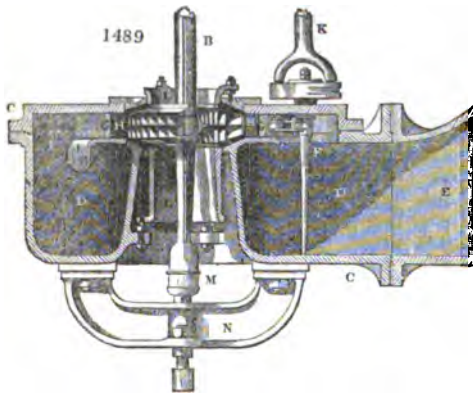
Vitriolic acid, or oil of vitriol, is sulphuric acid; blue vitriol, is sulphate of copper; green vitriol, is green sulphate of iron; vitriol of Mars, is red sulphate of iron; and white vitriol, is sulphate of zinc.

VORTEX WATER WHEEL. Numberless are the varieties, both of principle and of construction, to be met with in the mechanisms by which motive power may be obtained from falls of water. The chief modes of action of the water are, however, reducible to three, as follows. First:—The water may act directly, by its weight, on a part of the mechanism which descends while loaded with water, and ascends while free from load. The most prominent example of the application of this mode is afforded by the ordinary bucket water wheel. Second: The water may act by fluid pressure, and drive before it some part of the vessel, by which it is confined. This is the mode in which the water acts in the water-pressure-engine, analogous to the ordinary high pressure steam-engine. Third: The water, having been brought to its place of action, subject to the pressure due to the height of its fall, may be allowed to issue through small orifices with a high velocity, its inertia being one of the forces essentially involved in the communication of the power to the mechanism. Throughout the general class of wheels called Turbines, which is of wide extent, the water acts according to some of the variations of which this third mode is susceptible. The name

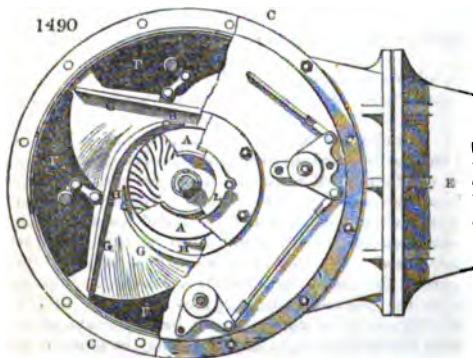
Turbine is derived from the Latin word *turbo*, a top, because the wheels to which it is applied almost all spin round a vertical axis, and so bear some considerable resemblance to the top. In our own country, and more especially on the continent, turbines have attracted much attention, and many forms of them have been made known, by published descriptions. The object of the present article is to give an account of a new water wheel, belonging to the same general class, which has been recently invented, patented, and brought successfully into use, by Mr. James Thomson, of Belfast. In this machine, the moving wheel is placed within a chamber of a nearly circular form. The water is injected into the chamber tangentially at the circumference, and thus it receives a rapid motion of rotation. Retaining this motion, it passes towards the centre, where, alone, it is free to make its exit. The wheel, which is placed within the chamber, and which almost entirely fills it, is divided by thin partitions into a great number of radiating passages. Through these passages the water must flow in its course towards the centre; and, in doing so, it imparts its own rotatory motion to the wheel. The whirlpool of water, acting within the wheel chamber, being one principal feature of this turbine, leads to the name *Vortex*, as a suitable designation for the machine as a whole.

The vortex admits of several modes of construction; but the two principal forms are the one adapted for high falls, and the one for low falls. The former may be called the high pressure vortex, and the latter the low pressure vortex. An example of each of these two kinds is delineated in the accompanying figures.

Figs. 1489. and 1490. are respectively a vertical section and a plan of a vortex recently



partition between the two divisions. This outer part of the upper division is called the *guide-blade chamber*, from its containing four guide blades, *c*, which direct the water tangentially into the wheel chamber. Immediately after being injected into the wheel



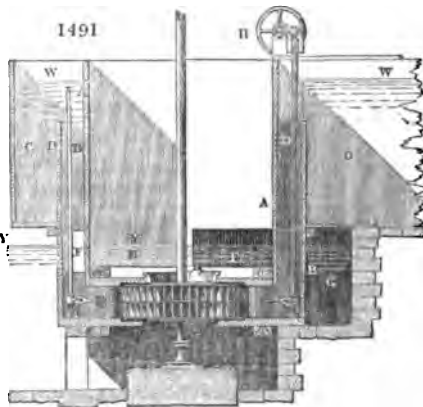
chamber the water is received by the curved radiating passages of the wheel, which are partly to be seen in *fig. 1490.* at a place where both the cover of the wheel chamber, and the upper plate of the wheel, are broken away for the purpose of exposing the interior to view. The water on reaching the inner ends of these curved passages, having already done its work, is allowed to make its exit by two large central orifices shown distinctly on the figures at or adjacent to the letters *L*, the one leading upwards and the other downwards. Close joints between the case and the wheel

* In these figures, as also in *Figs. 1491, 1492.*, some unimportant modifications are made for the purpose of simplifying the drawings, and rendering them more easily understood than they would otherwise be.

to hinder the escape of water otherwise than through the radiating passages, are made by means of two annular pieces *L, L*, called *joint rings*, fitting to the central orifices of the case, and capable of being adjusted, by means of studs and nuts so as to come close to the wheel, without impeding its motion by friction. The four openings *u, u*, *fig. 1490.*, through which the water flows into the wheel chamber, each situated between the point or edge of one guide-blade and the middle of the next, determine, by their width, the quantity of water admitted, and consequently the power of the wheel. To render this power capable of being varied at pleasure, the guide blades are made moveable round gudgeons or centres near their points; and a spindle *x*, worked by a handle in any convenient position, is connected with the guide-blades by means of links, cranks, &c. (see the figures) in such a way that when the handle is moved, the four entrance orifices are all enlarged or contracted alike. The gudgeons of the guide-blades, seen in *fig. 1490.* as small circles near the points, are sunk in sockets in the floor and roof of the guide-blade chamber, and so they do not in any way obstruct the flow of the water. *x* is the pivot box of the upright shaft, and is constructed with peculiar provisions for oiling the pivot, which, by reason of its being under water, does not admit of being oiled by ordinary means. *x* is a hanging bridge which forms the fixture of the pivot.

This vortex is calculated for 50 horse-power, with a fall varying from 90 to 100 feet. On account of the great height of the fall, the machine comes to be of very small dimensions; the diameter of the water wheel itself being only about 15 inches, and the extreme diameter of the case 3 feet 9 inches. The speed for which the wheel is calculated, in accordance with its diameter and the velocity of the water entering its chamber, is 768 revolutions per minute.

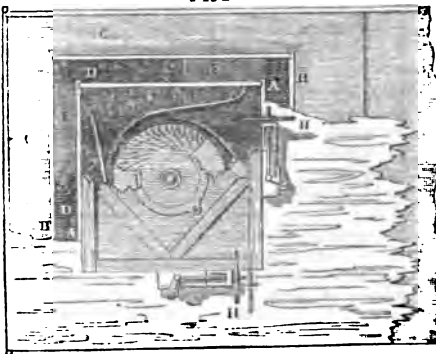
A low pressure vortex constructed for another mill near Belfast is represented in vertical



section and plan, in *figs. 1491. and 1492.* This is essentially the same in principle as the vortex already described, but it differs in the material of which the case is constructed, and in the manner in which the water is led to the guide blade chamber. In this the case is almost entirely composed of wood. The water flows with a free upper surface *w w*, into this wooden case, which consists chiefly of two tanks, *A A*, and *B B*, one within the other. The water-wheel chamber, and the guide-blade chamber, are situated in the open space between the bottom of the outer and that of the inner tank, and will be readily distinguished by reference to the figures. The water of the head race, having been led all round the

outer-tank in the space *c c*, flows inwards over its edge, and passes downwards by the space *d d*, between the sides of the two tanks. It then passes through the guide-blade chamber and the water-wheel, just in the same way as was explained in respect to the high pressure vortex already described; and in this

1492



one likewise it make its exit by two central orifices, the one discharging upwards, and the other downwards. The part of the water which passes downwards flows away at once to the tail race, and that which passes upwards into the space *z*, within the innermost tank, finds a free escape to the tail race through boxes and other channels, *v* and *o*, provided for that purpose. The wheel is completely submerged under the surface of the water in the tail race, which is represented at its ordinary level at *v v*, *fig. 1491.*, although in floods it may rise to a much greater height. The power of the wheel is regulated in a similar way to that already described, in reference to the high

pressure vortex. In this case, however, as will be seen by the figures, the guide-blades are not linked together, but each is provided with a hand wheel u , by which motion is communicated to itself alone.

The foregoing descriptions are sufficient to explain the principal points in the structural arrangements of these new water wheels.

And now a few words more in respect to their principles may be added. In these machines, the velocity of the circumference of the wheel is made the same as the velocity of the entering water, and thus there is no impact between the water and the wheel; but, on the contrary, the water enters the radiating conduits of the wheel gently, that is to say, with scarcely any motion in relation to their mouths. In order to attain the equalization of these velocities, it is necessary that the circumference of the wheel should move with the velocity which a heavy body would attain in falling through a vertical space equal to half the vertical fall of the water, or, in other words, with the velocity due to half the fall; and that the orifices through which the water is injected into the wheel chamber should be conjointly of such an area, that, when all the water required is flowing through them, it also may have the velocity due to half the fall.

Thus one half only of the fall is employed in producing velocity in the water; and, therefore, the other half still remains, acting on the water within the wheel chamber at the circumference of the wheel, in the condition of fluid pressure. Now, with the velocity already assigned to the wheel, it is found that this fluid pressure is exactly that which is requisite to overcome the centrifugal force of the water in the wheel, and to bring the water to a state of rest at its exit, the mechanical work due to both halves of the fall being transferred to the wheel during the combined action of the moving water and the moving wheel. In the foregoing statements, the effects of fluid friction, and of some other modifying influences, are for simplicity left out of consideration.

The discussion of such intricate matters would be unsuitable for the present article, the object of which was to give a full and clear description of the leading features of an invention, which is giving great satisfaction.

W.

WACKE, is a massive mineral, intermediate between claystone and basalt. It is of a greenish-gray colour; vesicular in structure; dull, opaque; streak shining; soft, easily frangible; spec. grav. 2.55 to 2.9; it fuses like basalt.

WADD, is the provincial name of plumbago in Cumberland; and also of an ore of manganese in Derbyshire, which consists of the peroxide of that metal, associated with nearly its own weight of oxide of iron.

WADDING (*Ouate*, Fr.; *Watte*, Germ.); is the spongy web which serves to line ladies' pelisses, &c. *Ouate*, or *Wat*, was the name originally given to the glossy downy tufts found in the pods of the plant commonly called *Apoeyn*, and by botanists *Asclepias syriaca*, which was imported from Egypt and Asia Minor for the purpose of stuffing cushions, &c. Wadding is now made with a lap or fleece of cotton prepared by the carding-engine (see *Carding*, COTTON MANUFACTURE), which is applied to tissue paper by a coat of size, made by boiling the cuttings of hare-skins, and adding a little alum to the gelatinous solution. When two laps are glued with their faces together, they form the most downy kind of wadding.

WAFERS. There are two manners of manufacturing wafers: 1, with wheat flour and water, for the ordinary kind; and 2, with gelatine. 1. A certain quantity of fine flour is to be diffused through pure water, and so mixed as to leave no clotty particles. This thin pap is then coloured with one or other of the matters to be particularly described under the second head; and which are, vermilion, sulphate of indigo, and gamboge. The pap is not allowed to ferment, but must be employed immediately after it is mixed. For this purpose a tool is employed, consisting of two plates of iron, which come together like pincers or a pair of tongs, leaving a certain small definite space betwixt them. These plates are first slightly heated, greased with butter, filled with the pap, closed, and then exposed for a short time to the heat of a charcoal fire. The iron plates being allowed to cool, on opening them, the thin cake appears dry, solid, brittle, and about as thick as a playing-card. By means of annular punches of different sizes, with sharp edges, the cake is cut into wafers. 2. The transparent wafers are made as follows:—

Dissolve fine glue, or isinglass, in such a quantity of water that the solution, when cold, may be consistent. Let it be poured hot upon a plate of mirror glass, (previously warmed with steam, and slightly greased), which is fitted in a metallic frame with edges just as high as the wafers should be thick. A second plate of glass, heated and greased, is laid on the surface, so as to touch every point of the gelatine, resting on the edges of the frame. By this pressure, the thin cake of gelatine is made perfectly

uniform. When the two plates of glass get cold, the gelatine becomes solid, and may easily be removed. It is then cut with proper punches into discs of different sizes.

The colouring matters ought not to be of an insalubrious kind.

For red wafers, carmine is well adapted, when they are not to be transparent; but this colour is dear, and can be used only for the finer kinds. Instead of it, a decoction of brazil wood, brightened with a little alum, may be employed.

For yellow, an infusion of saffron or turmeric has been prescribed; but a decoction of weld, fustic, or Persian berries, might be used.

Sulphate of indigo, partially saturated with potash, is used for the blue wafers; and this mixed with yellow, for the greens. Some recommend the sulphate to be nearly neutralized with chalk, and to treat the liquor with alcohol, in order to obtain the best blue dye for wafers.

Common wafers are, however, coloured with the substances mentioned at the beginning of the article; and for the cheaper kinds, red lead is used instead of vermilion, and turmeric instead of gamboge.

Three new methods of manufacturing wafers were made the subject of a patent by Peter Armand Le Comte de Fontainemoreau, in April, 1850; the chief feature of which is a layer of metal foil. In the first of the three forms described, the metal slip or band is to be coated with the ordinary farinaceous paste used for making wafers, for which purpose the slip is laid on one of the jaws of the ordinary iron mould, then a spoonful of paste is poured on it, the mould is shut, and the paste baked as usual. The metal band is lastly punched into wafers, either plain or ornamental.

The second method is to stick these slips to paper with paste, then to dry and punch them out.

By the third plan, strips of gummed paper are affixed to the slips, and a resinous cement is put on the other side. The first two methods require moistening, the third heating. This contrivance is susceptible of much variety of decoration.

WALNUT HUSKS, or PEELS (*Brout des noix, Fr.*); are much employed by the French dyers for rooting or giving dun colours.

WARES (HARD). Birmingham has long been connected with the manufacture of hardware of every kind, to such a degree that the name of the town has often become associated with these articles. Some departments of the trade are likewise vigorously pushed at Wolverhampton, Wallsall, and Sheffield; but Birmingham may be legitimately considered as the metropolis for hardware generally; and the enormous extension of its trade, attributable in a large measure to these manufactures, indicates the momentous results to which the production in quantities of the most trivial objects may give rise. In 40 years the population of Birmingham has increased by nearly 150 per cent.; and what is highly instructive and remarkable, is the fact that in proportion to the increase of production has been the decrease of price, until there has been a reduction in the same period of about 62 per cent., and in some articles to 85 per cent. The exports likewise immensely increased in the same time; at its commencement they slightly exceeded 5,800 tons annually; in 1849 the exports amounted to 23,421 tons, the value of which has been estimated at about 2,201,315*l.* sterling. This relates nearly to the iron manufactures: of the brass and copper manufactures were exported in 1849 to the value of 1,875,865*l.*; and it deserves notice that the greatest proportion of these manufactures absorbed by any country is that annually imported by Hindostan, a country whose early reputation in metal manufactures is a subject of familiar knowledge.

The system of the manufacture of hardware in Birmingham is peculiar, and presents a striking contrast to that adopted in Manchester and other large manufacturing places: the operatives are themselves the manufacturers. Hiring a workshop in which steam-power is laid on, and which is specially fitted up by the owner of the building, in which many such workshops are contained, the artizan plies his peculiar trade, manufactures his articles, carries them home to the merchant, and receives the weekly payment for them, which enables him to procure fresh materials, and proceed in the ensuing week with his regular labours. A very large proportion of hardware is thus manufactured. But this system is not universal, and regularly organized factories employing a large number of workpeople, and possessing all the distinguishing features of a great producing establishment, exist and are in active operation.

WARP (*Chaine, Fr.*; *Kette, Anschweif, Zettel, Germ.*); is the name of the longitudinal threads or yarns, whether of cotton, linen, silk, or wool, which being decussated at right angles by the woof or weft threads form a piece of cloth. The warp yarns are parallel, and continuous from end to end of the web. See WEAVING, for a description of the *warping-mill*.

WASH, is the fermented wort of the distiller.

WASHING. See BLEACHING and SCOURING.

WATERING OF STUFFS (*Moirage, Fr.*); is a process to which silk and

other textile fabrics are subjected, for causing them to exhibit a variety of undulated reflections, and plays of light. It is produced by sprinkling water upon the goods, and then passing them through a calender, either with cold or hot rollers, plain or variously indented.

WATER-PROOF CLOTH. See CAOUTCHOUC, and GELATINE.

A patent was obtained, in August, 1830, by Mr. Thomas Hancock, for rendering textile fabrics impervious to water and air, by spreading the liquid juice of the caoutchouc tree upon the surfaces of the goods, and then exposing them to the air to dry. It does not appear that this project has been realized in our manufactures.

Mr. William Simpson Potter proposes, in his patent, of April, 1835, to render fabrics water-proof by imbuing them with a solution of isinglass, alum, and soap, by means of a brush applied to the wrong side of the cloth, distended upon a table. After it is dry, it must be brushed on the wrong side, against the grain. Then the brush is to be dipped in clean water, and passed lightly over the cloth. The gloss caused by the above application can be taken off by brushing the goods when they are dry. Cloth so prepared is said to be impervious to water, but not to air.

I have examined woollen cloth now on sale in a shop in the Strand, which may be breathed through with the greatest facility, but which retains water upon its surface, as is evinced by a body of water standing upon a concave piece of it tied over a show-glass in the window.

Mr. Sievier's plan of rendering cloth water-proof, for which he obtained a patent in December, 1835, consists in spreading over it, with a brush, a solution of India rubber in spirits of turpentine, at one or more applications, and then applying a similar solution mixed with acetate of lead, litharge, sulphate of zinc, gum mastic, or other drying material. He next takes wool, or other textile material, cut into proper lengths, and spreads it upon the surface of the fabric varnished in this manner, for the purpose of forming the nap or pile. He then presses the cloth by means of rollers, or brushes, so as to fix the nap firmly to its surface.

Water-proof fustians are made on the patent process of Mr. Charles Townsend as follows: 20 lbs. of British gum are made into a paste with 8 gallons of water; then 10 lbs. of white soap are dissolved in 8 gallons of boiling water, and the two liquids are mixed with 1 pint of logwood liquor, and the whole boiled together; 3 lbs. of alum dissolved in 1 gallon of water are added, and the mixture after boiling for a few minutes is ready for use, or for applying by immersion to the cloth. He also uses sometimes two different solutions in succession, the one of which is 6 pounds of sulphate of zinc, dissolved in 9 gallons of boiling water, the other is the above mixture of gum and soap in solution. This combination will in my opinion make a preferable water-proofing application. The logwood may be left out for ordinary fabrics.

Water-proofing fleeces of sheep. The late Mr. James Smith, of Deanston, proposed to render the fleece of living sheep water-proof, by impregnating it first with a solution of alum, (20 pounds of alum to 40 gallons), and then with one of 30 pounds of soft soap in 40 gallons of hot water. The sheep are to be dipped in a trough, about 4 feet long, and 2½ feet wide; containing about 20 gallons of the solution of alum. The dipping is most conveniently performed by three men; two to hold the legs, and the other to hold the head out of the solution when the body is immersed. The sheep is to be held with its legs upwards, and the body dipped and moved about in the solution. The men who hold the legs must use one hand to rub the solution in amongst the fleece, and care should be taken to cause the solution to enter thoroughly in amongst the fibres. The operation of dipping a sheep will take about half a minute. It is then to be lifted out, and placed upon a board at the side of the trough, so arranged that the solution which drains off may run back into the trough, and the men are to press the liquid as much as possible out of the wool. After this the sheep is allowed to stand till its coat is nearly dry, which will be in about 2 hours, and then it is to be dipped in the solution of soap in the same manner as it was dipped in the alum solution. When the last dipping is completed, the sheep may go to its pasture. If the dipping is daily performed, each fibre of the fleece will possess the quality of repelling water, and thus the wool will be kept dry, the animal healthy and comfortable, and the wool improved for manufacturing purposes.

Instead of the solution of soap, a solution of glue or other gelatinous matter may be employed: arsenic, and preparations of sulphur for repelling insects, may be employed in conjunction with the above rain repellents, alternately, or mixed together. The above invention is patented in the name of Alexander Mein, and enrolled June, 1851. — *Newton's Journal*, xxxix. 154.

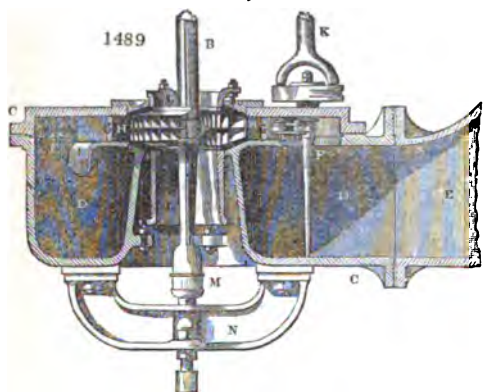
WATERS, MINERAL. The following Tables exhibit the Nature and Composition of the most celebrated Mineral Waters of Germany, according to the best Analyses. The symbol N denotes Nitrogen or Azote; O, Oxygen; CO², Carbonic Acid; SH, Sulphuretted Hydrogen. Therm.; cent. scale; if not, R. for Reaumur.

| Classification | Places | Specific Gravity and Temperature | Quantity | Gases | | | Carbonated Salts | | | Muricatic Salts | | | Sulphuric Salts | | | Other Constituents | Total | Author |
|--|--|----------------------------------|--------------------|--|---------------------------|----------------------------|------------------|-----------------------|---------|-----------------|---------|----------------|-----------------|--|---|---|--|-------------------|
| | | | | N. O. | CO ₂ | SH. | Iron-oxide | Soda | Line. | Mag-nesia | Soda | Line. | Mag-nesia | Soda | Line. | | | |
| 1. Fer- riferous Waters | Biberach (Moengrund in Mo- lase) Crailsheim (Kueper) Offenhaus (Muschelkalk) Ehrl (Muschelkalk) Rotenmünster, (Brine spring of Wilhelmshall) Schwemlingen, (Brine spring of Wilhelmshall) | 1-000906 | 1000 grammes | N + O 7-00 cub.in. | 65-083 N. 2 cub.in. | carb. in 16 oz. | 0-863 | 0-19 gr. in 16 oz. | 0-344 | Traces. | Traces. | Traces. | Traces. | Traces. | Silica, 0-084 gr. Organic Matter, 2-50 gr. In 16 oz. | 5-07 = 2-50 gr. In 16 oz. | C. Gmelin, Mayer, (Schulz, and Schulz, Handb. | |
| | | 80 | 16 oz. | 2-51 c. in. | 2-765 " | Traces. | 0-109 | 3-674 | 0-41 | 0-082 | 1-551 | 8-214 | 2-273 | Sulph. of Pot. 0-033 gr. Sulphur, 0-009 gr. Silica, 0-05 gr. | 15-794 53-31 | | | |
| | | 100 | 16 " | | | | 0-035 | 1-69 | | 0-67 | 1-44 | 9-18 | 1-44 | Organic Matter, 0-41 gr. | 173-16 | | | |
| | | 1-15553 Specific Gravity. | 100 lbs. | | | | | | | | 0-4986 | | | | | 25-6783 | | |
| | | 1-19719 | 100 " | | | | | | | | 0-3239 | | | | | 25-1855 | | |
| 2. Saline. | Mergentheim (Muschel- kalk) Cals., Artesian Spring, (Bunter Sandstein) | 1-012 | 16 oz. | | 13-53 " | | Traces. | 3-26 | 0-224 | 0-024 | 0-024 | 0-024 | 0-024 | 0-024 | Mineral Matter, 0-10 gr. Traces of Silica, 0-05 gr. Silica, 1-96 gr. | 34-2 33-5 56-631 | C. Gmelin, Wrede, (1856, Fiedersht. | |
| | | 8-90 | 100 " | | 8-035 " | | 0-02 | 4-10 | 0-53 | 4-5-10 | 7-00 | 7-45 | 0-86 | Traces of Silica, 0-05 gr. Nitrate of Pot., 13-039 | 13-59 | | | |
| | | 1-00865 | 100 " | N + O 79-25 " | 21-138 " | | 0-668 | 6-991 | 30-35 | 2-53 | 2-811 | 4-784 | 0-569 | 0-40 | Sulph. of Potash, 0-90 gr. Sulph. of Soda, 0-29 gr. a little Manganese Silica, 0-28 gr. a little Silica, 0-85 gr. a little little Magnesia | 13-59 | Sigwart and Wied. & Degen. | |
| | | 1006 | 16 " | 100 cub.in. | 100 " | | 0-2 | 0-53 | 0-54 | 0-70 | 1-82 | | | 0-40 | Silica, 8-41 gr. | 7-88 | Neschohd. | |
| | | 27-370 | 100 lbs. | 100 cub.in. | 100 " | | Traces. | 9-165 | 9-109 | 1-198 | 34-57 | | | 3-477 | Traces of Mur. of Soda, Magnesia, and Silica | 34-48 | Sigwart. | |
| 3. Ther- mal. | Wildbad (Granite) New Spring, 1836 Liesensal (Bunter Sand- stein and Granite) Tubingen (Wilhelmshal- brunnen, Kueper) Lorenstein (Thuesser) Moglingen (Chalkenohk Lias) Rietman (Kueper) | 1001-5 | 16 oz. | 44-17-4-5-25-51-58 100 43-1-18 39 | 51-58 " | | Traces. | 0-10 | 0-82 | | 0-14 | Traces. | 0-61 | Traces of Mur. of Soda, Magnesia, and Silica | 34-48 | Sigwart. | | |
| | | 17-3-19-30 | 16 " | 100 | 100 " | | 2-56 | 16-00 | 1-12 | | 2-40 | Frash. 3-40 | | | Resinous Extract | 18-40 | Sigwart. | |
| | | | 16 " | | 1-3 " | | | | 1-97 | 0-95 | | 0-35 | 1-1 | 11-28 | 2-75 | Traces of Carbonate of Iron and Magnesia | 18-05 | Sigwart. |
| | | | 16 " | | 0-06 " | | | | 2-85 | 0-57 | | 0-46 | 0-86 | 10-31 | 8-65 | Traces of Resin, Iron- oxide, Phosph. Acid and Silica, 1-575 gr. with Phosph. Acid | 77-1443 | Zwink. |
| | | | 100 " | | 21-9737 " | | | | 16-4082 | | | 2-7615 | 3-9192 | 18-750 | 8-4107 | Silica, 0-09 gr. Hyposul- phate of Alumina, 0-065 gr. Traces of Nitric and Sul- phuric Acids | 3-968 3-649 | Sulzer. Lembe. |
| 4. Cold non- ferrous- Waters. | Gisingen by Rens. (plus with Tiefgrund) Um (Griethal) Imnau (Muschel- kalk) Niederman (Muschel- kalk) Carls Spring | 1-0005 | 16 " | 0-59-1-0-06 cub. in. | 2-68 " | | 0-019 | 2-031 | 0-166 | 0-051 | 0-009 | 0-019 | 0-061 | | Silica, 0-09 gr. Hyposul- phate of Alumina, 0-065 gr. Traces of Nitric and Sul- phuric Acids | 3-968 3-649 | Sulzer. | |
| | | 6-6-50 | 16 " | | | | 0-044 | 1-625 | 0-105 | | 1-875 | | | | Traces of Nitric and Sul- phuric Acids | 3-968 3-649 | Sulzer. | |
| | | | 16 " | | N O = atm. air, 100 | 30-351 atm. air, 100 | | 0-55 | 6-833 | 0-089 | 1-044 | 0-536 | 0-221 | 0-335 | | Silica, 0-093 gr. Organic Matter, 1-130 gr. | 11-569 | Sigwart. |
| | | | 16 " | | > atm. air, 100 | 27-119 atm. air, 100 | | 0-564 | 6-629 | 0-429 | 0-078 | 0-045 | 0-487 | 0-140 | | Silica, 0-093 gr. Organic Matter, 0-430 gr. | 8-74 | Sigwart. |
| | | | 16 " | | < atm. air, 100 | 27-351 atm. air, 100 | | 0-564 | 4-166 | 0-356 | 0-134 | 0-138 | 0-157 | 0-381 | | Silica, 0-263 gr. Organic Matter, 0-622 gr. | 6-128 | Sigwart. |
| | 16 " | | 1-21 V. Traces. | 1-21 V. Traces. | | 0-08 | 7-44 | 0-86 | | 0-58 | 0-28 | 1-02 | 1-18 | Silica, 0-12 gr. Organic Matter, 0-01 gr. | 11-97 | C. Gmelin, Sigwart. | | |
| | 16 " | | 14 cub.in. | 14 cub.in. | | Traces. | 5-807 | 1-637 | | 0-214 | | 0-402 | | Asphalt, 0-010 gr. | 9-07 | Sigwart. | | |

Turbine is derived from the Latin word *turbo*, a top, and so bear some considerable resemblance to the top. In our own country, and more especially on the continent, turbines have attracted much attention, and many forms of them have been made known, by published descriptions. The object of the present article is to give an account of a new water wheel, belonging to the same general class, which has been recently invented, patented, and brought successfully into use, by Mr. James Thomson, of Belfast. In this machine, the moving wheel is placed within a chamber of a nearly circular form. The water is injected into the chamber tangentially at the circumference, and thus it receives a rapid motion of rotation. Retaining this motion, it passes towards the centre, where, alone, it is free to make its exit. The wheel, which is placed within the chamber, and which almost entirely fills it, is divided by thin partitions into a great number of radiating passages. Through these passages the water must flow in its course towards the centre; and, in doing so, it imparts its own rotatory motion to the wheel. The whirlpool of water, acting within the wheel chamber, being one principal feature of this turbine, leads to the name *Vortex*, as a suitable designation for the machine as a whole.

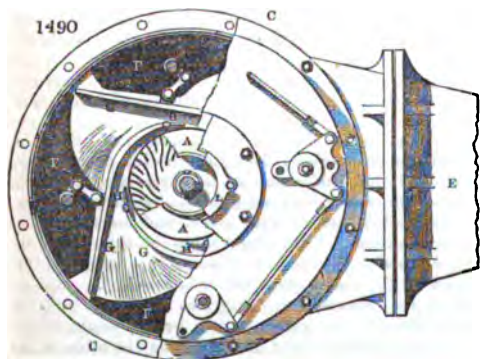
The vortex admits of several modes of construction; but the two principal forms are the one adapted for high falls, and the one for low falls. The former may be called the high pressure vortex, and the latter the low pressure vortex. An example of each of these two kinds is delineated in the accompanying figures.

Figs. 1489. and 1490. are respectively a vertical section and a plan of a vortex recently



constructed for employing a very high fall near Belfast to drive a flax-mill.* A A is the water wheel. It is fixed on the upright shaft x, which conveys away the power to the machinery to be driven. The water wheel occupies the central part of the upper division of a strong cast-iron case c c. This part of the case is called the *wheel chamber*. D D is the lower division of the case, and is called the *supply chamber*. It receives the water directly from the supply pipe, of which the lower extremity is shown at x, and delivers it into the outer part of the upper division by four large openings r, in the partition between the two divisions. This outer part of the upper division is called the *guide-blade chamber*, from its containing four guide blades, a, which direct the water tangentially into the wheel chamber. Immediately after being injected into the wheel chamber the water is received by the curved radiating passages of the wheel, which are partly to be seen in *fig. 1490.* at a place where both the cover of the wheel chamber, and the upper plate of the wheel, are broken away for the purpose of exposing the interior to view. The water on reaching the inner ends of these curved passages, having already done its work, is allowed to make its exit by two large central orifices shown distinctly on the figures at or adjacent to the letters L L, the one leading upwards and the other downwards. Close joints between the case and the wheel

partition between the two divisions. This outer part of the upper division is called the *guide-blade chamber*, from its containing four guide blades, a, which direct the water tangentially into the wheel chamber. Immediately after being injected into the wheel

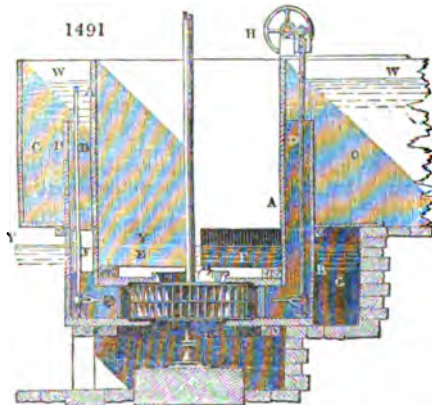


* In these figures, as also in *figs. 1491, 1492.*, some unimportant modifications are made for the purpose of simplifying the drawings, and rendering them more easily understood than they would otherwise be.

to hinder the escape of water otherwise than through the radiating vanes, by means of two annular pieces L, L, called *joint rings*, fitting the case, and capable of being adjusted, by means of studs and screws to the wheel, without impeding its motion by friction. The four openings through which the water flows into the wheel chamber, each at the outer edge of one guide-blade and the middle of the next, determine the quantity of water admitted, and consequently the power of the machine, the power capable of being varied at pleasure, the guide blades are supported by gudgeons or centres near their points; and a spindle x, working in a convenient position, is connected with the guide-blades by means of the figures) in such a way that when the handle is moved, the guide blades are all enlarged or contracted alike. The gudgeons of the guide-blades are small circles near the points, are sunk in sockets in the floor of the wheel chamber, and so they do not in any way obstruct the flow of the water in the box of the upright shaft, and is constructed with peculiar provisions which, by reason of its being under water, does not admit of any other means. N is a hanging bridge which forms the fixture of the machine.

This vortex is calculated for 50 horse-power, with a fall varying from 10 to 15 feet. On account of the great height of the fall, the machine comes to a stop when the diameter of the water wheel itself being only about 10 feet, the extreme diameter of the case 3 feet 9 inches. The speed for 50 horse-power is 768 revolutions per minute.

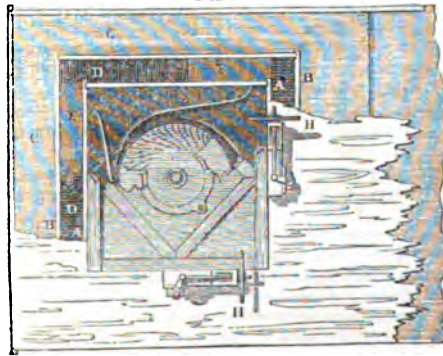
A low pressure vortex constructed for another mill near Belfast



section and 1492. This is in principle described, material of construction, which the blade chamber almost entirely. The water surface w w which contains A A, and B B. The water guide-blade in the bottom of the inner distinguishing figures.

outer-tank in the space c c, flows inwards over its edge, and space d d, between the sides of the two tanks. It then passes into the wheel chamber and the water-wheel, just in the same way as was explained in the high pressure vortex already described; and in this one likewise

1492



central or upwards. The part downwards the tail race upwards the inner escape the boxes are provided with a wheel at the tail at its ordinary although much greater of the similar described,

TABLE II. — MINERAL WATERS OF GERMANY — continued.

| Classification. | Places. | Specific Gravity at 15° C. | Quantity, gr. | Gases. | | Iron-salts. | | | Carbonated Salts. | | | Magnesian Salts. | | | Sulphuric Salts. | | | Other Constituents. | Total Solid Parts. | Author. |
|----------------------|---|----------------------------|---------------|-------------------------|--------|-------------------|-----|----------|---|-----------|----------|------------------|--------------|----------|--|---|--------------------|---------------------|--------------------|---------|
| | | | | N. | O. | CO ₂ . | Fe. | Soda. | Liase. | Magnesia. | Soda. | Liase. | Magnesia. | Soda. | Liase. | Magnesia. | Soda. | | | |
| 4. Acidulous Waters. | Oest. Baden (Friedrichsbad) | 1.004 | 16 | SH. 3.53 | 1.77 | - | - | 0.23 | 0.194 | 0.35 | 0.117 | 0.398 | 0.408 | 0.406 | Silica, 0.012 - Alumina, 0.1 - Silica, 0.2 - Extractive, 0.016 | 8.100 | Schub. | | | |
| | Landsk. St. Georgenbad (Gross) | 93.50 R. | 16 | SH. 4.333 | 1.25 | - | - | 0.132 | - | 0.068 | - | 0.838 | 0.400 | - | - | 1.997 | Magn. and Quatner. | | | |
| | Sejona (Eisenbühl) | 140 R. | 16 | - | 15.97 | - | - | 1.9672 | 1.9653 | - | - | 0.953 | - | - | Phosphate of Soda, 0.1823 | 36.1888 | Blasch. | | | |
| | Reichler, Trinklquelle | 86.50 R. | 16 | - | 19.86 | - | - | 3.1657 | 3.0628 | - | - | 8.6787 | - | - | Phosphate of Soda, 0.1840. Alumina, 0.008 | 80.7797 | - | | | |
| | Schwabheim (Bassit) | 1.0092 | 16 | N. 0.867 O. 0.192 | 37.65 | - | - | 0.775683 | 4.264948 | - | - | 0.777800 | 0.581830 Fe. | - | - | Alumina, 0.048637 Silica, 0.069419 | 17.86207 | Warms. | | |
| | Kleinheim, M. extr. (M. extr. - alk. and Phosph.) | 9.50 R. | 16 | - | 80.24 | - | - | 0.35 | 2.70 | 1.28 | 1.08 Fe. | 8.03 | 0.77 | - | - | Phosphate of Soda, 0.11. Trace of Alumina, 0.003. Magnesia, 0.003. | 30.98 | Kantner. | | |
| | Soden, Winklerbrunnen | 1.00749 | 16 | - | 16.569 | - | - | - | 5.068 | 3.647 | 4.07 Fe. | - | 0.328 | - | - | Silica, 0.17. Alumina, 0.029. Strontian, 0.002. Bromine and Iodine Salts | 51.171 | Schwalber. | | |
| | Salzkun, Oberbrunnen (Ubergangsbrunnen) | 1.00841 | 16 | - | 98 | - | - | 8.000 | 3.008 | 1.001 | - | - | 8.008 | - | - | Silica, 0.084 | 15.059 | Fischer. | | |
| | Pyritz (Ursprung, Grotte) | 9.50 R. | 16 | - | 100 | - | - | 1.6000 | 0.0013 | 0.0158 | - | - | 26.98000 | - | - | Phosphate of Lime 0.0280 Magnesia, | 44.8079 | Trommsdorff. | | |
| | Spardorf (Vulkanische Grotte) | 9.50 R. | 16 | - | 39.4 | - | - | 0.2000 | 7.1723 | 0.0158 | - | - | 0.7182 | 0.2156 | - | Silica, 0.0490 Alumina, 0.0080 Magnesia, 0.0080 Strontian, 0.0080 Potash, 0.0080 Soda, 0.0080 | 8.7884 | Bromm. | | |
| | Pyritz, additional (Lauer Sandstein) | 8.50 R. | 16 | - | 100 | - | - | 0.8089 | 1.8110 | 0.1884 | - | 0.1882 | 0.7182 | - | - | Phosphate of Lime 0.0280 Magnesia, 0.0080 Strontian, 0.0080 Potash, 0.0080 Soda, 0.0080 | 8.7884 | Bromm. | | |
| | Strombad (Bassit) | - | 16 | SH. 0.767 calc. Sal. | 0.834 | - | - | 0.426 | 0.83 | 0.087 | - | 0.214 | 1.364 | 0.809 | - | Extractive, 0.058 | 0.067 | Schub. | | |
| | Wellbach | - | 16 | SH. 4.0 | 9.0 | - | - | 4.500 | 2.125 | 1.250 | - | 0.930 | 1.125 | - | - | Sulphurous Acids, 0.275 | 11.056 | Carve. | | |
| | Nendorf, Spring under the Wall (Steinhöhlenlager) | 1.0082 90 R. | 16 | N. 0.72 SH. 1.19 | 2.61 | - | - | 3.90122 | 0.780078 | 0.418222 | - | 0.788027 | 0.187053 | 7.656118 | 0.708099 | Acids, 0.004973. Alumina, 0.007112. Alumina, 0.000004 | 18.467706 | Warms. | | |
| | Eisen, Georgenbrunnen (M. extr. - alk. and Phosph.) | 1.00775 9 - 10° R. | 16 | SH. 7.68 | 0.72 | - | - | 1.403 | 10.0 Sulph. - 10.0 Phosph. - 10.0 Hydrogen. | 0.264 | 0.461 | 1.200 | 0.7786 | 8.000 | - | Extractive, 0.06 Alumina, 0.119 Alumina, 0.048 | 33.847 | Wink. | | |

| Places. | Authors. | Quantity. | Combustible Matters. | Sulphur. | Resin. | Extensive. | Flux. | Silica. | Iron-oxide. | Oxide. | Alumina. | Classif. | Places. | Quantity. | Muriatic Salts. | Sulphuric Salts. | Other Matters, with the Total. | Authors. | | |
|--|----------|-------------------------|----------------------|--------------------|----------|------------|-------|---------|-------------|--------|----------|----------|---------|-----------|--------------------|-----------------------|--|----------|---------------|---|
| Melching, Schwefel, (Schwefelwasserstoff) | 16 | P. 141 O. 0-06 SH. 2-13 | 8-11 | 0-080 with Mangan. | 0-1725 | 1-1494 | - | - | - | - | - | - | - | - | 8-3853 3-0057 Pot. | 1-7353 0-048 Stewart. | Subphosphate of Alumina, 0-100 Silica, 0-12. Animal matter | 19-4894 | Brandes. | |
| Winstler, Spring | Sulphur | 110 R. | 1-0003 | 16 | SH. 13-0 | 10-0 | - | - | - | - | - | - | - | - | 17-166 | 6-135 | Alumina, 0-100. Silica, 0-150 | 38-616 | Unger. | |
| Langensais | - | 100 R. | SH. 5-723 | 1-626 | - | - | - | - | - | - | - | - | - | - | 11-150 | 2-000 | Sulphuric matter, 0-1. Silica, 0-15. Extractive, 0-075 | 30-075 | Tymann-Greif. | |
| Kruth, Steinsgraben | - | 90 R. | SH. 1-58 | 2-625 | 0-125 | - | - | - | - | - | - | - | - | - | 6-879 | 2-75 | Silica, 0-625. Humins, 0-125 | 17-00 | Vogel. | |
| Rekies, Schwefelstein (Fitzkauk with Basalt) | - | 1-0085 | SH. 0-2 | 2-10 | 0-40 | - | - | - | - | - | - | - | - | - | - | - | Humins, 0-01. Silica, 0-01 | 3-00 | - | |
| Rombheim | - | 16 | SH. 0-1 | - | 0-06 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1-24 | - |

| Places. | Authors. | Quantity. | Combustible Matters. | Sulphur. | Salts. | Oxide. | Alumina. | Classif. | Places. | Quantity. | Muriatic Salts. | Sulphuric Salts. | Other Matters, with the Total. | Authors. | |
|--------------------|------------|-----------|----------------------|----------|---|--|----------|--|---------|-----------|-----------------|---|--|-------------------------|------------------|
| Elisen | Westrumb. | 100 | 4-25 | 0-13 | 6-5 | 130 cal. 21-36 (with Silica). | 5-4 | 1-230 | 16 | 116-00 | 6-00 | 6-00 | Veget. soil, 1-0 Extractive, 0-66 Carb. of Lime, 0-4 | Ruhm. Schindler Becker. | |
| Freudl | Wising. | 100 | 0-75 | 0-0 | 28-3 Sol. } 2-4 25-81 Insol. } 18-0 } 15-60 } 15-60 } 15-60 } 15-60 } | 0-25 0-25 0-25 0-25 0-25 0-25 0-25 | 0-5 | 16 | 179-33 | 7-0 | 11-0 | Carb. of Lime, 0-4 Rauhaus matter, 0-5 | 158-4 | Pfaff. | |
| Granzbad | Bauhals | 1000 | 0-75 | 0-0 | 110-0 | 110-0 | 43-0 | 109-402 | 16 | 1-0 | 5-075 | 10-600 | Carb. of Lime and Red Oxide, 3-20 Iron, 0-36 Extractive, 0-48 Silica, 0-250 | 160-116 | Herrn- adult. |
| Oestr. Bodenschant | - | 840 | 81-8 | - | 16-18 | 16-18 | 0-923 | Carbonic Acid, 2-973 cub. in. Aste, 0-923 cub. in. | - | - | - | - | - | - | |
| Mertinsbad | Steinmann. | 8123 | - | - | 16-18 | 16-18 | 0-923 | - | - | - | - | - | - | | |

C. K. B. B.

TABLE III ANALYSES OF THE PRINCIPAL MINERAL WATERS OF GERMANY.

| Grades of Anhydrous Ingredients in One Pound Dry. | Carbonat. | Ess. | Sulphuric-Oxalic-Ironum. | Martianic Acid. | Ammoniac-Ferrous-Ironum. | Mag. Phosphate-Ironum. | Pyromet. | Sig. Phos. | Phosphog. | Calcium. | Sulphur. | Sulphuric. | Phos. |
|---|--|-------------------------|--------------------------|-----------------|--------------------------|------------------------|----------|------------|------------|----------|----------|------------|----------|
| Carbonate of Soda | 7-2713 | 8-0695 | 6-1138 | 5-3499 | 4-3676 | 3-9314 | - | 0-5531 | 12-3328 | 4-9668 | 4-6162 | - | - |
| Ditto of Lithia | 0-0180 | 0-0405 | 0-0187 | 0-0868 | 0-0507 | 0-0283 | - | - | - | - | 0-0114 | 0-0144 | - |
| Ditto of Barita | - | 0-0093 | - | - | - | - | - | - | - | 3-2279 | 1-4004 | 0-9775 | - |
| Ditto of Strontia | - | 0-0080 | - | - | - | - | - | - | - | 1-6283 | 1-5000 | 0-8285 | - |
| Ditto of Lime | 0-0066 | 0-0085 | 0-0165 | 0-0098 | 0-0040 | 0-0028 | 4-7781 | 0-7287 | - | - | 0-0117 | 0-0095 | 0-0096 |
| Ditto of Magnesia | 1-0776 | 3-9509 | 1-7407 | 3-9509 | 3-0085 | 1-3501 | 0-7881 | 0-7287 | 1-9667 | 3-2279 | 1-4004 | 0-9775 | - |
| Do. (Proto) of Manganes. | 0-0048 | 0-0078 | 1-1107 | 0-0280 | 3-2867 | 0-6040 | 0-0864 | 0-0889 | 0-6481 | 1-6283 | 0-0093 | 0-0093 | 4-9045 |
| Ditto (Proto) of Iron. | 0-0048 | 0-0190 | 0-0490 | 0-0288 | 0-3995 | 0-1763 | 0-3318 | 0-0102 | 0-0061 | - | 0-0007 | 0-0088 | - |
| Sub-Phos. of Lime | 0-0012 | 0-0014 | 0-0045 | 0-1819 | 0-0040 | 0-0029 | 0-0110 | 0-0094 | 0-0061 | - | 0-0007 | 0-0088 | 0-0096 |
| Ditto of Alumina | 0-0019 | 0-0030 | 0-0045 | - | 0-0040 | 0-0029 | 0-0314 | 0-0094 | - | 0-2154 | 0-2978 | 0-6705 | 3-8000 |
| Sulphate of Potassa | - | - | 3-2985 | - | 16-9023 | 18-3755 | 1-6092 | 0-0281 | 0-0281 | 0-0315 | 0-2978 | 17-6320 | 92-8500 |
| Ditto of Soda | 14-9019 | - | - | 26-2698 | - | - | 0-0067 | - | 0-1267 | - | - | - | - |
| Ditto of Lithia | - | - | - | - | - | - | 0-0065 | - | - | - | - | 1-1297 | 1-3600 |
| Ditto of Strontia | - | - | - | - | - | - | 0-0134 | - | - | - | - | 62-3347 | 69-3145 |
| Ditto of Barita | - | - | - | - | - | - | 3-3894 | - | - | - | - | 5-8809 | - |
| Ditto of Magnesia | - | 0-0036 | - | - | - | - | - | - | - | - | - | - | - |
| Chlor. of Potassium | 5-9820 | 5-7385 | 0-6752 | 10-1737 | 6-7472 | 6-9280 | - | 0-3271 | 3-3387 | 0-4073 | 0-2685 | 12-6690 | - |
| Ditto of Sodium | 00-184 | 0-0014 | - | 0-0028 | - | - | 0-6450 | - | - | 0-4073 | 0-0013 | 12-6690 | - |
| Fluoride of Calcium | - | - | - | - | - | - | - | - | - | 00-185 | - | 0-0013 | 1-3235 |
| Alumina | 0-4239 | 0-3104 | 0-2831 | 0-2906 | 0-5023 | 0-2646 | 0-2727 | 0-2729 | 0-0897 | 0-2021 | 0-2265 | 0-0900 | 14-7495 |
| Total | 31-4605 | 16-0635 | 13-9163 | 49-6417 | 34-4719 | 31-6670 | 16-4321 | 3-2629 | 18-9300 | 9-6966 | 21-2923 | 98-0133 | 186-4806 |
| Carbonic Acid Gas in 100 cubic Inches | 86 | 81 | 98 | 105 | 146 | 154 | 160 | 136 | 135 | 163 | 136 | 20 | 7 |
| Temperature (° F.) | Signal. 139° Numb. 139° Muhl. 139° Ther. 139° | Keat. 119° Klth. 80° | 89° | 89° | 49° | 89° | 69° | 80° | 80° | 81° | 80° | 80° | 80° |
| Analyzed by | Berzelius. | Struve. | Struve. | Berzelius. | Stedemann. | Berzelius. | Struve. | Struve. | Blochhoff. | Struve. | Struve. | Struve. | Struve. |

TABLE IV.—The Composition of other celebrated Mineral Waters.

| Names of the Springs. | Grains of water. | Cubic Inches of Gases. | | | Carbonates of | | | Sulphates of | | | Nitrates of | | | Silica. | Alu- minia. | Fer- rous Oxide. | Tem- per- ature. |
|------------------------------|------------------|------------------------|----------------|------------------|---------------|-------|-----------|--------------|-------|-----------|-------------|-------|--------------|---------|-------------|------------------|------------------|
| | | Oxy- gen. | Carbolic acid. | Sulph. hydrogen. | Soda. | Lime. | Magnesia. | Soda. | Lime. | Magnesia. | Soda. | Lime. | Magn. Oxide. | | | | |
| Kilburn (1) — acidulous. | 138940 | - | 84.0 | 36.0 | grs. | grs. | grs. | grs. | grs. | grs. | grs. | grs. | grs. | grs. | grs. | grs. | cold |
| Harrogate (2) | 108648 | - | 8.0 | 19.0 | - | 18.5 | 5.5 | - | 0.5 | - | 61.5 | 3.0 | 9.1 | - | - | - | cold |
| Mids (3) | 108648 | - | 1.0 | 10.0 | - | 18.25 | 5.89 | - | - | - | 3.6 | 3.6 | 3.6 | - | - | - | cold |
| Aix-la-Chapelle (3) | 8940 | - | 18.5 | 17.06 | - | 18.25 | 5.89 | - | - | - | 6.21 | 6.21 | 6.21 | - | - | - | 148° |
| Engeln (4) | 93180 | - | - | 7.0 | - | 31.4 | 1.35 | - | 33.3 | 5.8 | 2.4 | 2.4 | 8.0 | - | - | - | cold |
| Selters | 66309 | - | 8.0 | 3.0 | - | 6.7 | 31.0 | 5.0 | 41.1 | 14.44 | - | - | 36.5 | - | - | - | cold |
| Cheltenham (6) | 102648 | - | 20.3 | 12.0 | - | 0.4 | 12.5 | 5.0 | 46.0 | 40.0 | - | - | 5.0 | - | - | - | cold |
| Prometaria (6) | 14600 | - | - | - | - | 0.8 | - | 1.0 | 1.0 | 1.0 | - | - | 21.0 | - | - | - | cold |
| Dumblane (7) sp. gr. 1.00475 | 7291 | - | 1.0 | - | - | 0.5 | - | 0.17 | 0.9 | - | - | - | 12.7 | - | - | - | cold |
| Ficantilly (7) | 7291 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | cold |
| Tunbridge (8) | 108648 | 1.4 | 10.6 | - | - | - | - | 1.0 | - | 1.25 | - | 11.2 | 0.5 | 2.25 | - | - | cold |
| Brighton (8) | 66309 | - | 18.0 | - | - | 16.9 | - | 33.8 | - | 33.7 | - | - | 12.2 | 6.0 | - | - | cold |
| Toplis (9) | 32340 | - | - | - | - | - | - | - | - | - | - | - | 61.3 | 26.6 | - | - | cold |
| Chaly- beate. | | | | | | | | | | | | | | | | | |
| Bath (10) | 13860 | - | 2.4 | - | - | 1.6 | - | 0.004 | 3.0 | 18.0 | - | - | 6.6 | - | - | - | 114° |
| Buxton (11) | 66309 | - | - | - | - | 10.5 | - | - | 3.5 | 3.5 | - | - | 1.5 | - | - | - | 82° |
| Bristol (12) | 66309 | - | 30.8 | - | - | 13.6 | - | - | 11.2 | 11.7 | - | - | 4.0 | 7.26 | - | - | 74° |
| Malvern (13) | 66309 | - | - | - | - | 1.6 | - | 0.93 | 2.886 | - | - | - | 1.55 | - | - | - | 69° |
| Calcareous, nearly pure. | | | | | | | | | | | | | | | | | |
| Dead Sea (14) sp. gr. 1.211 | 100 | - | - | - | - | - | - | - | - | 064 | - | - | 10.676 | 3.8 | 10.1 | - | 114° |
| Do. (15) sp. gr. 1.245 | - | - | - | - | - | - | - | - | - | - | - | - | 7.8 | 10.6 | 24.2 | - | 82° |
| Do. (16) sp. gr. 1.588 | - | - | - | - | - | - | - | - | - | - | - | - | 6.95 | 4.0 | 15.21 | - | 74° |
| See water, Forth (7) | 791 | - | - | - | - | - | - | - | - | - | - | - | 159.3 | 8.7 | 82.5 | - | 69° |

(1) Schmeisser. (2) Gaurak. (3) Balington. (4) Fontroy. (5) Fothergill. (6) Vauquelin. (7) Dr. Murray. (8) Marce. (9) John. (10) Phillips. (11) Pearson. (12) Carrick. (13) Dr. Phillip. (14) Dr. Marce. (15) Dr. Wollaston. (16) M. Gay Lussac.

Mineral waters may, in most cases, be artificially prepared, by the skilful application of the knowledge derived from analysis, with such precision as to imitate very closely the native springs. When the various earthy or metallic constituents are held in solution by carbonic acid, or sulphuretted hydrogen, they should be placed along with their due proportions of water, in the receiver of the aerating machine (see *SODA WATER*), and then the proper quantity of gas should be injected into the water. Sufficient agitation will be given by the action of the forcing pump to promote their solution.

Analysis of the Bromine Mineral Spring or Well of Tenbury, Worcestershire, the Property of S. Holmes Godson, Esq. By methods somewhat similar to those described in my paper on the "Analysis of the Moira Brine Spring," which the Royal Society honoured with a place in their *Transactions* for 1834, part ii., I obtained the following results from one gallon = 70,000 water-grain measures = 1 gallon:—

| | grains. |
|---|---------|
| 1. Chlorosodium (muriate of soda) - - - | 1301·4 |
| 2. Chlorcalcium (muriate of lime) - - - | 425·6 |
| 3. Chlormagnesium (muriate of magnesia) - - - | 51·3 |
| 4. Sulphate of lime - - - | 6·0 |
| 5. Protocarbonate of iron - - - | 1·5 |
| 6. Bromide of sodium (bromosodium) - - - | 16·2 |

Total saline contents = 1802·0

Specific gravity of the water at 60° F. = 1·0208

Taste, bitter saline, but not unpleasantly so.

This water has been long prized for its medicinal virtues as a deobstruent. In reference to the bromine constituent, it is doubly richer than the Moira spring water.

The determination of the presence and approximate proportion of bromine in such a saline water is attended with no difficulty. Having concentrated a considerable quantity of it by evaporation to such a pitch as to separate the greater part of the readily crystallizable muriate of soda, add to the filtered mother-water a small portion of pretty strong chlorine-water. The bright golden yellow colour immediately produced indicates the bromine, now eliminated from its state of hydrobromic acid. Ether being poured into the bottle partially filled with the saline solution, and agitated therewith, seizes the bromine, and on repose rises with it, and floats in a rich crimson solution on the top of the decoloured liquor. Care must be taken that chlorine has not been used in excess, otherwise the next processes would be vitiated, which consist, first, in decanting the ethereous compound, and saturating it with pure potash lye, so as to form bromide of potassium. This solution being evaporated, and gently ignited, is to be supersaturated with nitric acid, the bromine precipitated with nitrate of silver, and the brown silver bromide washed, filtered, dried, and gently ignited. 100 parts of that bromide represent 41·5 of bromine. In Mr. Godson's mineral spring, there are very nearly 12½ grains of bromine per gallon, which are therefore worth extracting on the large scale from the water.

The ether, which has been stripped of its bromine by potash lye, may be nearly all recovered, with proper precautions, so as to be repeatedly applied to fresh quantities of chlorified mother-water. If the bromide of potassium be mixed with one-third of its weight of peroxide of manganese, and the mixture distilled with its own weight of sulphuric acid diluted with half its weight of water, from a retort whose beak dips into a receiver containing water, the bromine which comes over falls to the bottom, and may be entirely de-hydrated by re-distillation over chlorcalcium (calcined muriate of lime).

The bromine may also be extracted, and that very economically, by distilling the chlorified mother-water of the spring with the mixture of manganese and oil of vitriol. The bromine which passes over may be afterwards purified by washing with water, and then by the process above described, with potash, nitric acid, &c. — *Dr. Ure in Pharmaceutical Journal*, 1848, vol. viii. No. 4.

Nanheim, a spa recently discovered on the south-eastern declivity of Johannesburg, about an hour from Frankfurt-on-the-Mayne by railway, displays the phenomenon called *soolen sprudel*, or salt water jet; a column of white foam bubbling up 2 or 3 feet, with carbonic acid gas, 670 feet above the level of the sea. It is an Artesian well; the water has a specific gravity of 1·007 at 72·5° Fahr. Its chief constituents are muriate of soda with some muriate of potash, magnesia, and lime; the last abundant, with bromide of sodium.

A saline spring containing in 16 oz. 256 grains of sea salt, 8½ of muriate of magnesia, with sulphates of magnesia and lime in considerable quantity, and of spec. grav. 1·017, has been a few years ago discovered at Oeynhausen, near Minden upon the Weser. It is in the immediate vicinity of an immense brine spring which throws up 54 cubic feet

of salt water containing 416 grains in 10,000 of saline matter at a temperature of 95° Fahr. This spring contains also some bromine, and throws out jets of carbonic acid gas. This well has the prodigious depth of 1994 feet below the level of the sea; and its mouth is 217 feet above it. Here there have been 67 baths of different classes established. The whole has been well investigated and placed under the superintendence of Dr. Bischoff, Professor of Chemistry in Bonn.

WAX (*Cire*, Fr.; *Wachs*, Germ.): is the substance which forms the cells of bees. It was long supposed to be derived from the pollen of plants, swallowed by these insects, and merely voided under this new form; but it has been proved by the experiments, first of Mr. Hunter, and more especially of M. Huber, to be the peculiar secretion of a certain organ, which forms a part of the small sacs situated on the sides of the median line of the abdomen of the bee. On raising the lower segments of the abdomen, these sacs may be observed, as also scales or spangles of wax, arranged in pairs upon each segment. There are none, however, under the rings of the males and the queen. Each individual has only eight wax sacs, or pouches; for the first and the last ring are not provided with them. M. Huber satisfied himself by precise experiments that bees, though fed with honey or sugar alone, produced nevertheless a very considerable quantity of wax; thus proving that they were not mere collectors of this substance from the vegetable kingdom. The pollen of plants serves for the nourishment of the larvæ.

But wax exists also as a vegetable product, and may, in this point of view, be regarded as a concrete fixed oil. It forms a part of the green scudula of many plants, particularly of the cabbage; it may be extracted from the pollen of most flowers; as also from the skins of plums, and many stone fruits. It constitutes a varnish upon the upper surface of the leaves of many trees, and it has been observed in the juice of the cow-trees. The berries of the *Myrica angustifolia*, *latifolia*, as well as the *cerifera*, afford abundance of wax.

Bees' wax, as obtained by washing and melting the comb, is yellow. It has a peculiar smell, resembling honey, and derived from it, for the cells in which no honey has been deposited yield a scentless white wax. Wax is freed from its impurities, and bleached, by melting it with hot water or steam, in a tinned copper or wooden vessel, letting it settle, running off the clear supernatant oily-looking liquid into an oblong trough with a line of holes in its bottom, so as to distribute it upon horizontal wooden cylinders made to revolve half immersed in cold water, and then exposing the thin ribbons or films thus obtained to the blanching action of air, light, and moisture. For this purpose, the ribbons are laid upon long webs of canvas stretched horizontally between standards, two feet above the surface of a sheltered field, having a free exposure to the sunbeams. Here they are frequently turned over, then covered by nets to prevent their being blown away by winds, and watered from time to time, like linen upon the grass field in the old method of bleaching. Whenever the colour of the wax seems stationary, it is collected, re-melted, and thrown again into ribbons upon the wet cylinder, in order to expose new surfaces to the blanching operation. By several repetitions of these processes, if the weather proves favourable, the wax eventually loses its yellow tint entirely, and becomes fit for forming white candles. If it be finished under rain, it will become gray on keeping, and also lose in weight.

In France, where the purification of wax is a considerable object of manufacture, about four ounces of cream of tartar, or alum, are added to the water in the first melting-copper, and the solution is incorporated with the wax by diligent manipulation. The whole is left at rest for some time, and then the supernatant wax is run off into a settling cistern, whence it is discharged by a stopcock or tap, over the wooden cylinder revolving at the surface of a large water-cistern, kept cool by passing a stream continually through it.

The bleached wax is finally melted, strained through silk sieves, and then run into circular cavities in a moistened table, to be cast or moulded into thin disc pieces, weighing from two to three ounces each, and three or four inches in diameter.

Neither chlorine, nor even the chlorides of lime and alkalis, can be employed with any advantage to bleach wax, because they render it brittle, and impair its burning quality.

Wax purified, as above, is white and translucent in thin segments; it has neither taste nor smell; it has a specific gravity of from 0.960 to 0.966; it does not liquefy till it be heated to 154½° F.; but it softens at 86°, becoming so plastic that it may be moulded by the hand into any form. At 32° it is hard and brittle.

It is not a simple substance, but consists of two species of wax, which may be easily separated by boiling alcohol. The resulting solution deposits, on cooling, the waxy body called *cerine*. The undissolved wax, being once and again treated with boiling alcohol, finally affords from 70 to 90 per cent. of its weight of *cerine*. The insoluble residuum is the *myricine* of Dr. John, so called because it exists in a much larger proportion in the wax of the *Myrica cerifera*. It is greatly denser than wax, being of the

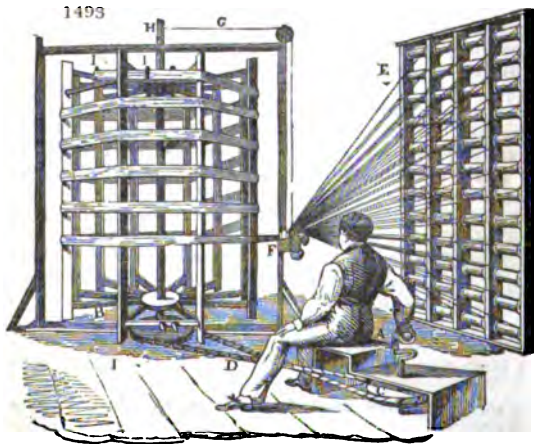
same specific gravity as water; and may be distilled without decomposition, which cerine undergoes. See these two articles.

Wax is adulterated sometimes with starch; a fraud easily detected by oil of turpentine, which dissolves the former, and leaves the latter substance; and more frequently with mutton suet. This fraud may be discovered by dry distillation; for wax does not thereby afford, like tallow, sebacic acid (benzoic), which is known by its occasioning a precipitate in a solution of acetate of lead. It is said that two per cent. of a tallow sophistication may be discovered in this way.

Bees' wax imported for home consumption:— in 1835, unbleached, 4,449 cwts.; bleached, 243 cwts.;— in 1836, unbleached, 4,673 cwt.; bleached, 121 cwts. Duty, when from British possessions, 10s.; from foreign, 30s.

WAX, MINERAL, or *Ozocerite*, is a solid, of a brown colour, of various shades, translucent, and fusible like bees' wax; slightly bituminous to the smell, of a foliated texture, a conchoidal fracture, but wanting tenacity, so that it can be pulverized in a mortar. Its specific gravity varies from 0.900 to 0.953. Candles have been made of it in Moldavia, which give a tolerable light. It occurs at the foot of the Carpathians near Slanik, beneath a bed of bituminous slate-clay, in masses of from 80 to 100 pounds weight. Layers of brown amber are found in the neighbourhood. It is associated with variegated sandstone, rock salt, and beds of coal (lignite?). It is analogous to *hatchetine*. Something similar has been discovered in a *trouble* at Urpeth colliery, near Newcastle, 60 fathoms beneath the surface. *Ozocerite* consists of different hydro-carburetted compounds associated together; the whole being composed, ultimately, of— hydrogen 14, carbon 86, very nearly.

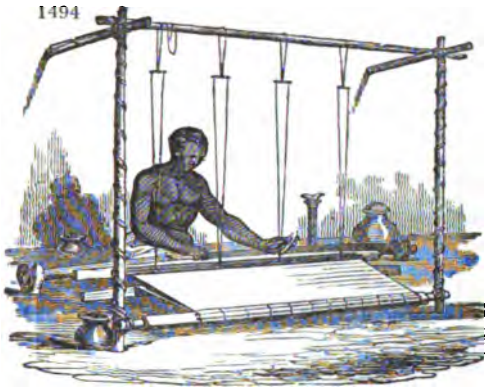
WEAVING (*Tissage*, Fr.; *Weberet*, Germ.); is performed by the implement called *loom* in English, *métier à tisser* in French, and *weberstuhl* in German. The process of warping must always precede weaving. Its object is to arrange all the longitudinal threads, which are to form the web, alongside of each other in one parallel plane. Such a number of bobbins, filled with yarn, must therefore be taken as will furnish the quantity required for the length of the intended piece of cloth. One-sixth of that number of bobbins is usually mounted at once in the warp mill, being set loosely in a horizontal direction upon wire skewers, or spindles, in a square frame, so that they may revolve, and give off the yarn freely. The warper sits at *a*, *fig.* 1493., and causes the reel *b* to revolve, by turning round with his hand the wheel *c*, with the



endless rope or band *p*. The bobbins filled with yarn are placed in the frame *z*. There is a sliding piece at *r*, called the *heck* box, which rises and falls by the coiling and uncoiling of the cord *c*, round the central shaft of the reel *n*. By this simple contrivance, the band of warp-yarns is wound spirally, from top to bottom, upon the reel. *1, 2, 1, 1*, are wooden pins which separate the different bands. Most warping mills are of a prismatic form; having twelve, eighteen, or more sides. The reel is commonly about six feet in diameter, and seven feet in height, so as to serve for measuring exactly upon its periphery the total length of the warp. All the threads from the frame *z* pass through the heck *r*, which consists of a series of finely-polished hard-tempered steel pins, with a small hole at the upper part of each, to receive and guide one thread. The heck is divided into two parts, either of which may be lifted by a small handle below, while their eyes are placed alternately. Hence, when one of them is raised a little, a vacuity is formed between the two bands of the warp; but when the other is raised, the vacuity is reversed. In this way, the lease is produced at each end of the warp, and it is preserved by appropriate wooden pegs. The lease being carefully tied up, affords a guide to the weaver for inserting his lease-rods. The warping mill is turned alternately from right to left, and from left to right, till a sufficient number of yarns are coiled round it to form the

breadth that is wanted; the warper's principal care being to tie immediately every thread as it breaks, otherwise deficiencies would be occasioned in the chain, injurious to the appearance of the web, or productive of much annoyance to the weaver.

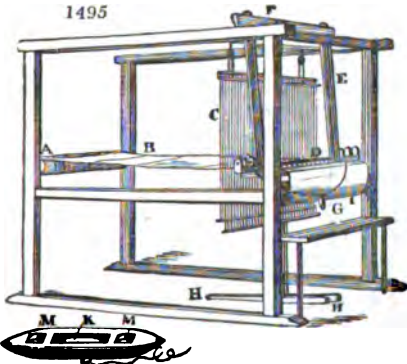
The simplest and probably the most ancient of looms, now to be seen in action, is that of the Hindu tanty, shown in *fig. 1494*. It consists of two bamboo rollers; one for



the warp, and another for the woven cloth; with a pair of heddles, for parting the warp, to permit the weft to be drawn across between its upper and under threads. The shuttle is a slender rod, like a large netting needle, rather longer than the web is broad, and is made use of as a batten or lay, to strike home or condense each successive thread of weft, against the closed fabric. The Hindu carries this simple implement, with his water pitcher, rice pot, and hooka, to the foot of any tree which can afford him a comfortable shade; he there digs a large hole, to receive

his legs, along with the treddles or lower part of the harness; he next extends his warp, by fastening his two bamboo rollers, at a proper distance from each other, with pins, into the sward; he attaches the heddles to a convenient branch of the tree overhead; inserts his great toes into two loops under the geer, to serve him for treddles; lastly, he sheds the warp, draws through the weft, and beats it close up to the web with his rod-shuttle or batten.

The European loom is represented in its plainest state, as it has existed for several centuries, in *fig. 1495*. A is the warp-beam, round which the chain has been wound; B represents the flat rods, usually three in number, which pass across between its threads, to preserve the lease, or the plane of decussation for the weft; C shows the heddles or



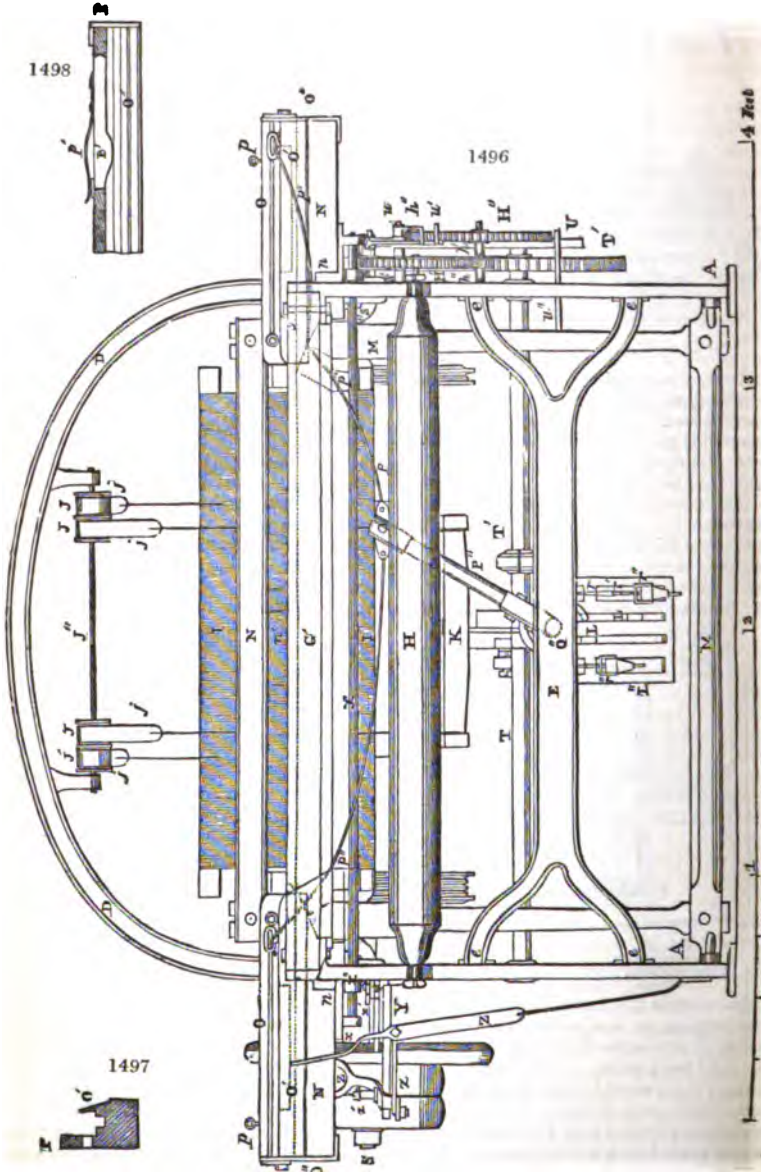
heads, consisting of twines looped in the middle, through which loops the warp yarns are drawn, one half through the front heddle, and the other through the back one; by moving which, the decussation is readily effected. The yarns then pass through the dents of the reed under D, which is set in a movable swing-frame K, called the lathe, lay, and also batten, because it beats home the weft to the web. The lay is freely suspended to a cross-bar F, attached by rulers, called the swords, to the top of the lateral standards of the loom, so as to oscillate upon it. The weaver, sitting on the bench G, presses down one of the treddles at H, with one of his feet, whereby he raises the corresponding heddle, but sinks the alternate one; thus sheds the warp, by lifting and depressing each alternate thread, through a little space, and opens a pathway or race-course

for the shuttle to traverse the middle of the warp, upon its two friction rollers M, M. For this purpose, he lays hold of the picking-peg in his right hand, and with a smart jerk of his wrist drives the fly-shuttle swiftly from one side of the loom to the other, between the shed warp yarns. The shoot of weft being thereby left behind from the shuttle pirn or cop, the weaver brings home, by pulling, the lay with its reed towards him by his left hand, with such force as the closeness of the texture requires. The web, as thus woven, is wound up by turning round the cloth beam I, furnished with a ratchet-wheel, which takes into a holding tooth. The plan of throwing the shuttle by the picking-peg and cord, is a great improvement upon the old way of throwing it by hand. It was contrived upwards of a century ago, by John Kay, of Bury, in Lancashire, but then resident in Colchester, and was called the fly-shuttle, from its speed, as it enabled the weaver to make double the quantity of narrow cloth, and much more broad cloth, in the same time.

The cloth is kept distended, during the operation of weaving, by means of two pieces

of hard wood, called a templet, furnished with sharp iron points in their ends, which take hold of the opposite selvages or lists of the web. The warp and web are kept longitudinally stretched by a weighted cord, which passes round the warp-beam, and which tends continually to draw back the cloth from its beam, where it is held fast by the ratchet tooth. See FUSTIAN, JACQUARD LOOM, REED, and TEXTILE FABRICS.

The greater part of plain weaving, and much even of the figured, is now performed by



the power loom, called *métier mécanique à tisser* in French. Fig. 1496. represents the cast-iron power loom of Sharp and Roberts. A, A', are the two side uprights, or standards, on the front of the loom. D, is the great arch of cast-iron, which binds the two sides together. X, is the front cross-beam, terminating in the forks e, e; whose

ends are bolted to the opposite standards Δ , Δ' , so as to bind the framework most firmly together. α' is the breast beam, of wood, nearly square; its upper surface is sloped a little towards the front, and its edge rounded off, for the web to slide smoothly over it, in its progress to the cloth beam. The beam is supported at its end upon brackets, and is secured by the bolts g' , g' . α is the cloth beam, a wooden cylinder, mounted with iron gudgeons at its ends, that on the right hand being prolonged to carry the toothed winding wheel n' . k' is a pinion in gear with n' . n'' is a ratchet wheel, mounted upon the same shaft k'' , as the pinion k' . k' is the click of the ratchet wheel n'' . k''' is a long bolt fixed to the frame, serving as a shaft to the ratchet wheel n'' , and the pinion k' . i is the front heddle-leaf, and i' the back one. j , j' , j' , jacks or pulleys and straps, for raising and depressing the leaves of the heddles. j'' is the iron shaft which carries the jacks or system of pulleys j , j' , j' . x , a strong wooden ruler, connecting the front heddle with its treddle. L , L' , the front and rear marches or treddle-pieces for depressing the heddle leaves alternately, by the intervention of the rods k , (and k' , hid behind k). m , m , are the two swords (swing bars) of the lay or batten. n is the upper cross-bar of the lay, made of wood, and supported upon the squares of the levers n' , to which it is firmly bolted. n' is the lay-cap, which is placed higher or lower, according to the breadth of the reed; it is the part of the lay which the handloom weaver seizes with his hand, in order to swing it towards him. n' is the reed contained between the bar n , and the lay-cap n' . o , o , are two rods of iron, perfectly round and straight, mounted near the ends of the batten-bar n , which serves as guides to the drivers or peckers o , o , which impel the shuttle. These are made of buffalo hide, and should slide freely on their guide-rods. o' , o' , are the fronts of the shuttle-boxes; they have a slight inclination backwards; r is the back of them. See *figs.* 1497. and 1498. o'' , o'' , are iron plates, forming the bottoms of the shuttle-boxes. p , small pegs or pins, planted in the posterior faces r (*fig.* 1496.) of the boxes, round which the levers r' turn. These levers are sunk in the substance of the faces r , turn round pegs p , being pressed from without inwards, by the springs p' . r'' , *fig.* 1496. (to the right of r .) is the whip or lever, (and q' , its centre of motion, corresponding to the right arm and elbow of the weaver,) which serves to throw the shuttle, by means of the pecking-cord p' , attached at its other end to the drivers o , o .

On the axis of q' , a kind of eccentric or heart wheel is mounted, to whose concave part, the middle of the double band or strap r , being attached, receives impulsion; its two ends are attached to the heads of the bolts r' , which carry the stirrups r'' , that may be adjusted at any suitable height, by set screws.

s (see the left-hand side of *fig.* 1496.), is the moving shaft, of wrought iron, resting on the two ends of the frame. s' (see the right-hand side), is a toothed wheel, mounted exteriorly to the frame, upon the end of the shaft s . s'' (near s'), are two equal elbows in the same direction, and in the same plane, as the shaft s , opposite to the swords m , m , of the lay.

z , is the loose, and z' , the fast pulley, or riggers, which receive motion from the steam-shaft of the factory. z'' , a small fly wheel, to regulate the movements of the main shaft of the loom.

t , is the shaft of the eccentric tappets, cams, or wipers, which press the treddle levers alternately up and down; on its right end is mounted t' , a toothed wheel in gear with the wheel s' , of one half its diameter. t'' , is a cleft clamping collar, which serves to support the shaft t .

u , is a lever, which turns round the bolt u , as well as the click n'' . u' is the click of traction, for turning round the cloth beam, jointed to the upper extremity of the lever u ; its tooth u' , catches in the teeth of the ratchet wheel n'' . u'' is a long slender rod, fixed to one of the swords of the lay m , serving to push the lower end of the lever u , when the lay retires towards the heddle leaves.

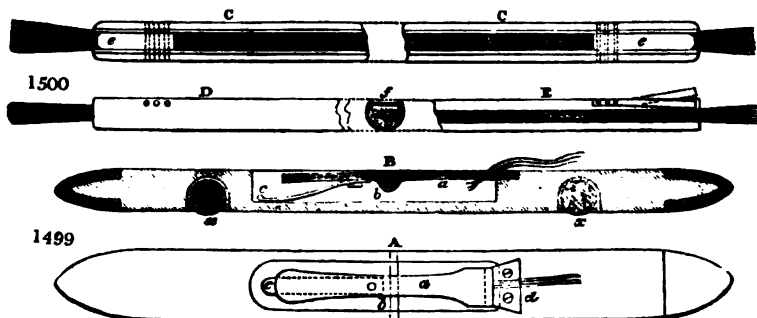
x , is a wrought-iron shaft, extending from the one shuttle-box to the other, supported at its ends by the bearings x , x .

y , is a bearing, affixed exteriorly to the frame, against which the spring bar z rests near its top, but is affixed to the frame at its bottom. The springs falls into a notch in the bar z , and is thereby held at a distance from the upright Δ , as long as the band is upon the loose pulley z' ; but when the spring bar is disengaged, it falls towards Δ , and carries the band upon the fast pulley z , so as to put the loom in gear with the steam-shaft of the factory.

Weaving, by this powerful machine, consists of four operations: 1. to shed the warp by means of the heddle leaves, actuated by the tappet wheels upon the axis q' , the rods k , k' , the cross-bar x , and the eyes of the heddle leaves i , i' ; 2. to throw the shuttle (see *fig.* 1495.), by means of the whip lever r' , the driver cord p , and the pecker o ; 3. to drive home the web by the batten n , n' ; 4. to unwind the chain from the warp beam, and to draw it progressively forwards, and wind the finished web upon the cloth beam α , by the click and toothed wheel mechanism at the right-hand side of the frame. For

more minute details, the reader may consult *The Cotton Manufacture of Great Britain*, vol. ii. p. 291.

WEAVING OF HAIR CLOTH. In addition to the description of this art under **HAIR**, I shall give here a short notice of the best kind of shuttle for weaving hair. *Fig. 1499.* shows in plan *A*, and in longitudinal section *B*, a shuttle which



differs from that of the common cloth weaver only in not having a pirn enclosed in the body of the box-wood, but merely an iron trap *a*, which turns in the middle upon the pin *b*. This trap-piece is pressed up at the one end, by the action of the spring *c*, so as to bear with its other end upon the cleft of the iron plate *d*, which is intended to hold fast the ends of the hair-weft: *d* and *c* together are called the jaw or mouth, whence the popular name of this shuttle. The workman opens this jaw by the pressure of his thumb upon the spring end of the trap *a*, introduces with the other hand one or more hairs (according to the description of hair cloth) into the mouth, and removing his thumb, lets the hairs be seized by the force of the spring. The hairs having one end thus made fast are passed across the warp by the passage of the shuttle, which is received at the other end by the weaver's left hand. The friction rollers, *x, x*, are like those of fly-shuttles, but are used merely for convenience, as the shuttle cannot be thrown swiftly from side to side. The hand which receives the shuttle opens at the same time the trap, in order to insert another hair, after the preceding has been drawn through the warp on both sides and secured to the list. A child attends to count and stretch the hairs. This assistant may, however, be dispensed with by means of the following implement, represented in *fig. 1500*. *c, c*, is the view of it from above or the plan; *B*, is a side view; *x*, a longitudinal section, and *F*, an oblique section across. The chief part consists in a wooden groove, or chamfered slip of wood, open above, and rounded on the sides. It is about twenty-one inches in length, about as long nearly as the web is broad, therefore a little shorter than the horse-hairs inserted in it, which project about an inch beyond it at each end. They are herein pressed down by elastic slips, *e*, of Indian rubber, so that the others remain, when one or more are drawn out by the ends. The ends of the grooves are flat where the Indian rubber spring exerts its pressure, as shown by the dotted line at *F*. The spring is formed by cutting out a double piece from the curvature of the neck of a caoutchouc bottle or flask, fastening the one end of the piece by a wire staple in the groove of the shuttle, whereby the other end, which alone can yield, presses upon the inlaid hairs. Wire staples like *f*' (in the section *x*) are passed obliquely through two places of the groove or gutter, to prevent the hairs from springing up in the middle of the shuttle, which is suitably charged with them. The workman shoves the tool across the opened warp with the one hand, seizes with the other the requisite number of hairs by the projecting ends, and holds them fast while he draws the shuttle once more through the warp. The remaining hairs are retained in the groove by the springs, and only those for the single decussation remain in the web, to be secured to the list on either side. A weaver with this tool can turn out a double length of cloth of what he could do with the mouth-shuttle.

WEFT (*Trame*, Fr.; *Eintrag*, Germ.); is the name of the yarns or threads which run from selvage to selvage in a web.

WELD (*Vouëde*, Fr.; *Wau*, *Gelbkraut*, Germ.); is an annual herbaceous plant which grows all over Europe, called by botanists *Reseda luteola*. The stems and the leaves dye yellow; and among the dyes of organic nature, they rank next to the Persian berry for the beauty and fastness of colour. The whole plant is cropped when in seed, at which period its dyeing power is greatest; and after being simply dried, is brought into the market.

Chevreul has discovered a yellow colouring principle in weld which he has called

luteoline. It may be sublimed, and thus obtained in long needle-form, transparent, yellow crystals. Luteoline is but sparingly soluble in water; but it nevertheless dyes alumed silk and wool of a fine jonquil colour. It is soluble in alcohol and ether; it combines with acids, and especially with bases.

When weld is to be employed in the dye-bath, it should be boiled for three quarters of an hour; after which the exhausted plant is taken out, because it occupies too much room. The decoction is rapidly decomposed in the air, and ought therefore to be made only when it is wanted. It produces with,

| | | | | |
|-------------------------------|---|---|---|------------------------------|
| Solution of isinglass | - | - | - | a slight turbidity. |
| Litmus paper | - | - | - | a faint reddening. |
| Potash lye | - | - | - | a golden yellow tint. |
| Solution of alum | - | - | - | a faint yellow. |
| Protoxide salts of tin | - | - | - | a rich yellow |
| Acetate of lead | - | - | - | ditto |
| Salts of copper | - | - | - | a dirty yellow-brown |
| Sulphate of red oxide of iron | - | - | - | a brown, passing into olive. |

} precipitation.

A lack is made from decoction of weld with alum, precipitated by carbonate of soda or potassa. See YELLOW DYE.

WELDING (*Souder*, Fr.; *Schweissen*, Germ.); is the property which pieces of wrought iron possess, when heated to whiteness, of uniting intimately and permanently under the hammer, into one body, without any appearance of junction. The welding temperature is usually estimated at from 60° to 90° of Wedgewood. When a skilful blacksmith is about to perform the welding operation, he watches minutely the effect of the heat in his forge-fire upon the two iron bars; and if he perceives them beginning to burn, he pulls them out, rolls them in sand, which forms a glassy silicate of iron upon the surface, so as to prevent further oxidizement; and then laying the one properly upon the other, he incorporates them by his right-hand hammer, being assisted by another workman, who strikes the metal at the same time with a heavy forge-hammer.

Platinum is not susceptible of being welded, as many chemical authors have erroneously asserted.

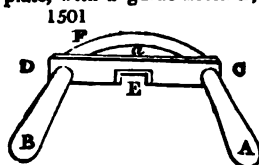
Mr. T. H. Russel, of Handsworth, near Birmingham, obtained a patent, in May, 1836, for manufacturing welded iron tubes, by drawing or passing the skelp, or fillet of sheet iron, five feet long, between dies or holes, formed by a pair of grooved rollers, placed with their sides contiguous; for which process, he does not previously turn up the skelp from end to end, but he does this so as to bring the edges together at the time when the welding is performed. He draws the skelp through two or more pairs of the above pinners or dies, each of less dimension than the preceding. In making tubes of an inch of internal diameter, a skelp four inches and a half broad is employed. The twin rollers revolve on vertical axes, which may be made to approach each other to give pressure; and they are kept cool by a stream of water, while the skelp, ignited to the welding heat, is passed between them. They are affixed at about a foot in front of the mouth of the furnace, on a draw-bench; there being a suitable stop within a few inches of the rollers, against which the workman may place a pair of pincers, having a bell-mouthed hole or die, for welding and shaping the tube. In the first passage between the rollers, a circular revolving plate of iron is let down vertically between them, to prevent the edges of the skelp from overlapping, or even meeting. The welding is performed at the last passage.

WELLS, ARTESIAN. See also **ARTESIAN WELLS.** The following account of a successful operation of this kind, lately performed at Mortlake, in Surrey, deserves to be recorded. The spot at which this undertaking was begun is within 100 feet of the Thames. In the first instance, an auger, seven inches in diameter, was used in penetrating 20 feet of superficial detritus, and 200 feet of London clay. An iron tube, 8 inches in diameter, was then driven into the opening, to dam out the land-springs and the percolation from the river. A 4-inch auger was next introduced through the iron tube, and the boring was continued until, the London clay having been perforated to the depth of 240 feet, the sands of the plastic clay were reached, and water of the softest and purest nature was obtained; but the supply was not sufficient, and it did not reach the surface. The work was proceeded with accordingly; and after 55 feet of alternating beds of sand and clay had been penetrated, the chalk was touched upon. A second tube, 4½ inches in diameter, was then driven into the chalk, to stop out the water of the plastic sands; and through this tube an auger, 3½ inches in diameter, was introduced, and worked down through 35 feet of hard chalk, abounding with flints. To this succeeded a bed of soft chalk, into which the instrument suddenly penetrated to the depth of 15 feet. On the auger being withdrawn, water gradually rose to the surface and overflowed. The expense of the work did not exceed 300*l*. The general summary

of the strata penetrated is as follows:—Gravel, 20 feet; London clay, 250; plastic sands and clays, 55; hard chalk with flints, 35; soft chalk, 15—375 feet.

WHALEBONE (*Baleine*, Fr.; *Fischbeine*, Germ.); is the name of the horny laminae, consisting of fibres laid lengthways, found in the mouth of the whale, which, by the fringes upon their edges, enable the animal to allow the water to flow out, as through rows of teeth (which it wants), from between its capacious jaws, but to catch and detain the minute creatures upon which it feeds. The fibres of whalebone have little lateral cohesion, as they are not transversely decussated, and may, therefore, be readily detached in the form of long filaments or bristles. The *blades*, or scythe-shaped plates, are externally compact, smooth, and susceptible of a good polish. They are connected, in a parallel series, by what is called the *gum* of the animal, and are arranged along each side of its mouth, to the number of about 300. The length of the longest *blade*, which is usually found near the middle of the series, is the gauge adopted by the fishermen to designate the size of the fish. The greatest length hitherto known has been 15 feet, but it rarely exceeds 12 or 13. The breadth, at the root end, is from 10 to 12 inches; and the average thickness, from four to five tenths of an inch. The series, viewed altogether, in the mouth of the whale, resemble, in general form, the roof of a house. They are cleansed and softened before cutting, by boiling for two hours in a long copper.

Whalebone, as brought from Greenland, is commonly divided into portable junks or pieces, comprising ten or twelve blades in each; but it is occasionally subdivided into separate blades, the gum and the hairy fringes having been removed by the sailors during the voyage. The price of whalebone fluctuates from 50*l.* to 150*l.* per ton. The blade is cut into parallel prismatic slips, as follows:—It is clamped horizontally, with its edge up and down, in the large wooden vice of a carpenter's bench, and is then planed by the following tool: *fig.* 1501. *a, a*, are its two handles; *c, d*, is an iron plate, with a guide-notch *x*; *r*, is a semicircular knife, screwed firmly at each end to the ends of the iron plate *c, d*, having its cutting edge



adjusted in a plane, so much lower than the bottom of the notch *x*, as the thickness of the whalebone slip is intended to be for different thicknesses: the knife may be set by the screws at different levels, but always in a plane parallel to the lower guide surface of the plate *c, d*. The workman, taking hold of the handles *a, a*, applies the notch of the tool at the end of the whalebone blade furthest from him, and with his two hands pulls it steadily along, so as to shave off a slice in the direction of the fibres; being careful to cut none of them across. These prismatic slips are then dried, and planed level upon their other two surfaces. The fibrous matter detached in this operation, is used, instead of hair, for stuffing mattresses.

From its flexibility, strength, elasticity, and lightness, whalebone is employed for many purposes; for ribs to umbrellas or parasols; for stiffening stays; for the framework of hats, &c. When heated by steam, or a sand bath, it softens, and may be bent or moulded, like horn, into various shapes, which it retains, if cooled under compression. In this way, snuff-boxes, and knobs of walking-sticks, may be made from the thicker parts of the blade. The surface is polished at first with ground pumice-stone, felt, and water; and finished with dry quicklime, spontaneously slaked, and sifted.

A patent was granted to Mr. Laurence Kortright in March, 1841, for improvements in the treatment of whalebone, which consist in compressing the strips in width to increase their thickness, so as to render the material applicable for forming walking-sticks, whip handles, parasol and umbrella sticks, ramrods, archery bows, &c. He accomplishes this by bending the strips together, introducing them into a steam chest, thereby softening them, and in that state compressing them into a compact mass by appropriate machinery; for a description, with figures, of which, see *Newton's Journal*, C. S., xxi. 444.

Although all the species of *Balena* possess this substance, it is furnished in the largest quantities, and of the finest quality, by the *Balena mysticetus*, which is the object of incessant and eager pursuit, not only for the value of this substance, but for the immense supply of oil which is obtained from the thick layer of blubber, or cutaneous fat, in which the body is enveloped. The length of the largest piece of baleen in a whale 60 feet long, is frequently as much as 12 feet, and the laminae are arranged in two series, each containing about 300 in number.

The fins or plates of baleen, or whalebone, of an inequilateral form, the largest, which are of most value in commerce, being arranged in a single longitudinal series on each side of the upper jaw of the "whalebone whales," (*Balenidæ*.) descending vertically and ending in a fringe of bristles: the smaller plates are arranged in oblique series, internal to the marginal ones. The base of each plate is hollow, and is fixed upon a pulp developed from a vascular germ, which is attached to a broad and shallow de-

pression occupying the whole of the palatal surface of the maxillary bones. The plates are so disposed as that their fringed terminations are directed downwards and inclining towards the back part of the mouth, and they prevent the escape of the small marine animals which constitute the food of the great whales (*Balaenæ*), for the prehension of which this singular substitute is adapted. The baleen plates are smallest at the two extremities of the series; the large intermediate one sometimes attains the length of 15 feet, being above a foot broad at the base. There are about 200 plates in outer row on each side of the mouth in the "true whale" (*Balæna mysticetus*). Each plate consists of a central coarse fibrous substance and an exterior compact fibrous layer: but this reaches to a certain extent only, beyond which the central part projects in the form of a fringe of bristles. The chemical base of baleen is albumen hardened by a small proportion of phosphate of lime. The baleen plates of the finners or hump-backed whales (*Balænoptera*) are smaller and of less value than those from the true whale (*Balæna mysticetus*).

WHEAT. (*Triticum vulgare*, Linn.; *Froment*, Fr.; *Waizen*, Germ.) See BREAD, GLUTEN, and STARCH.

WHEAT FLOUR; to detect adulteration of. Potato starch is insoluble in cold water, unless it be triturated in thin portions in a mortar. If pure wheat flour be thus triturated, it affords no trace of starch to iodine, as the former does, because the particles of wheat starch are very minute and are sheathed in gluten.

Bean flour digested with water at a heat of 68° Fahr. and triturated affords on filtration a liquid which becomes milky on the addition of a little acetic acid, by its reaction on the legumine present in the beans.

WHEEL CARRIAGES. Though this manufacture belongs most properly to a treatise upon mechanical engineering, I shall endeavour to describe the parts of a carriage, so as to enable gentlemen to judge of its make and relative merits. The external form may vary with every freak of fashion; but the general structure of a vehicle, as to lightness, elegance, and strength, may be judged of from the following figure and description.

Fig. 1502. shows the body of a chariot, hung upon an iron carriage, with iron wheels, axletrees, and boxes; the latter, by a simple contrivance, is close at the out-head, by which means the oil cannot escape; and the fastening of the wheel being at the in-head, as will be explained afterwards, gives great security, and prevents the possibility of the wheel being taken off by any other carriage running against it.

Fig. 1503. shows the arm of an axletree, turned perfectly true, with two collars in the solid, as seen at *c* and *n*. The parts from *c* to *s* are made cylindrical. At *x* is a screw nail, the purpose of which will be explained in *fig. 1507*.

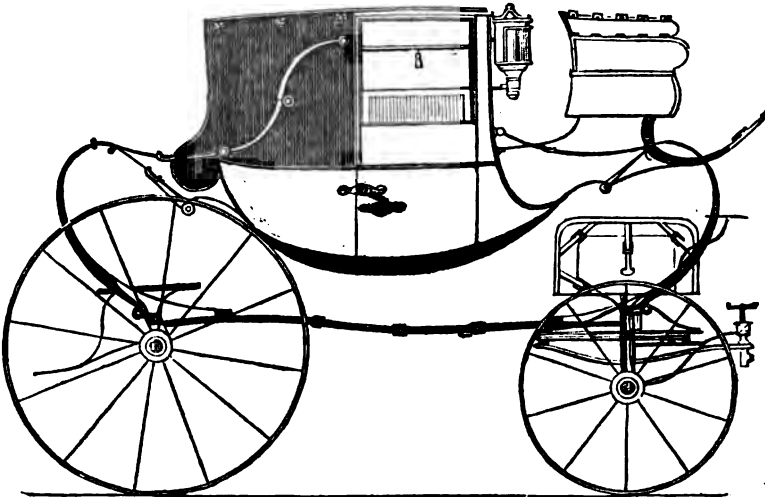


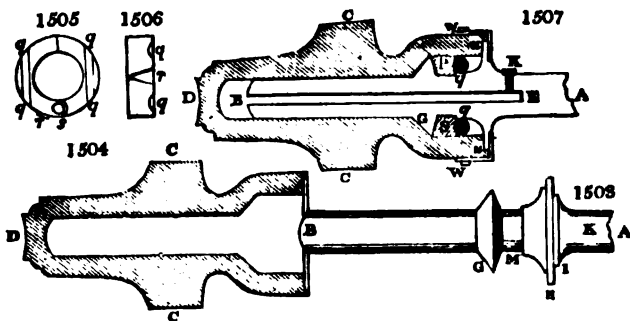
Fig. 1504. is the longitudinal section of a metal nave, which also forms the bush, for the better fitting of which to the axletree, it is bored out of the solid, and made quite air-tight upon the pin; and for retaining the oil, it is left close at the out-head *n*.

Fig. 1505. represents a collet, made of metal, turned perfectly true, the least diameter

of which is made the same with that part of the axletree *x*, *fig. 1503.*, and its greatest diameter the same with that of the solid collar *c*, *fig. 1503.* This collet is made with a joint at *s*, and opens at *p*. Two grooves are represented at *q, q*, which are seen at the same letters in *fig. 1506.*, as also the dovetail *r*, in both figures.

Fig. 1506. is an edge view of the collet, *fig. 1505.*

Fig. 1507. is a longitudinal section of an axletree arm, nave or bush, and fastening. *A, B,* is the arm of the axletree, bored up the centre from *x* to *c, c, c, d,* the nave, which



answers also for the bush *r, s*, the collet (see *figs. 1505.* and *1506.*), put into its place, *g, g*, two steel pins, passing through the in-head of the bush, and filling up the grooves in the collet, *w, w*, a caped hoop, sufficiently broad to cover the ends of said pins, and made fast to the bush by screws. This hoop, when so fastened to the bush, prevents the possibility of the pins *g, g*, from getting out of their places. *v, u*, is a leather washer, interposed betwixt the in-head of the bush and the larger solid collar of the axletree, to prevent the escape of oil at the in-head. *x*, is a screw, the head of which is near the letter *x*, in *fig. 1503.* This screw being undone, and oil poured into the hole, it flows down the bore in the centre of the axletree arm, and fills the space *z*, left by the arm being about one inch shorter than the bore of the bush, and the screw, being afterwards replaced, keeps all tight. In putting on the wheel, a little oil ought to be put into the space betwixt the collet *r, s*, and the larger collar. The collar *r, s*, being moveable round the axletree arm, and being made fast to the bush by means of the two pins *g, g*, revolves along with the bush, acting against the solid collar *c*, of the arm, and keeps the wheel fast to the axletree, until by removing the caped hoop *w, w*, and driving out the pins *g, g*, the collet becomes disengaged from the bush.

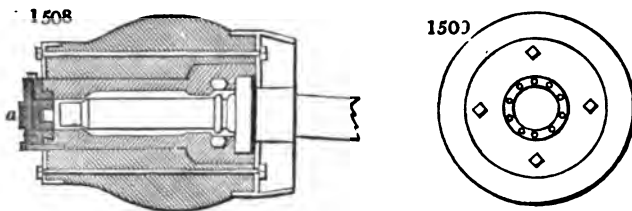
The dovetail, seen upon the collet at *r*, *fig. 1506.*, has a corresponding groove cut in the bush to receive it, in consequence of which the wheel must of necessity be put on so that the collet and pins fit exactly. These wheels very rarely require to be taken off, and they will run a thousand miles without requiring fresh oiling.

The spokes of the wheel, made of malleable iron, are screwed into the bush or nave at *c, c*, *figs. 1504.* *1507.*, all round. The felloes, composed merely of two bars of iron, bent into a circle edgewise, are put on, the one on the front, the other on the back, of the spokes, which have shoulders on both sides to support the felloes, and all three are attached together by rivets through them. The space between the two iron rings forming the felloes, should be filled up with light wood, the tire then put on, and fastened to the felloes by bolts and glands claspings both felloes.

This is a carriage without a mortise or tenon, or wooden joint of any kind. It is, at an average, one-seventh lighter than any of those built on the ordinary construction.

The design of Mr. W. Mason's patent invention, of 1827, is to give any required pressure to the ends of what are called mail axletrees, in order to prevent their shaking in the boxes of the wheels. This object is effected by the introduction of leather collars in certain parts of the box, and by a contrivance, in which the outer cap is screwed up, so as to bear against the end of the axletree with any degree of tightness, and is held in that situation, without the possibility of turning round, or allowing the axletree to become loose.

Fig. 1508. shows the section of the box of a wheel, with the end of the axletree secured in it. The general form of the box, and of the axle, is the same as other mail axles, there being recesses in the box for the reception of oil. At the end of the axle, a cap *a*, is inserted, with a leather collar enclosed in it, bearing against the end of the axle; which cap, when screwed up sufficiently tight, is held in that situation by a pin or screw passed through the cap *a*, into the end of the iron box; a representation of this end of the iron box being shown at *fig. 1509.*



In the cap *a*, there is also a groove for conducting the oil to the interior of the box, with a screw at the opening, to prevent it running out as the wheel goes round.

The particular claims of improvement are, the leather collar against the end of the axle; the pin going through one of the holes in the end of the box, to fix it; and the channel for conducting the oil.

Mr. Mason's patent, of August, 1830, applies also to the boxes and axles of that construction of carriage wheels which are fitted with the so-called mail-boxes; but part of the invention applies to other axles.

Fig. 1510. represents the nave of a wheel, with the box for the axle within it, both shown in section longitudinally; fig. 1511. is a section of the axle, taken in the same direction; and fig. 1512. represents the screw cap and oil-box, which attaches to the outer extremity of the axle-box. Supposing the parts were put together, that is, the axle inserted into the box, then the intention of the different parts will be perceived.

The cylindrical recess *a*, in the box of the nave, is designed to fit the cylindrical part of the axle *b*; and the conical part *c*, of the axle, to shoulder up against a corresponding conical cavity in the box, with a washer of leather to prevent its shaking. A collar *d*, formed by a metallic ring, fits loosely upon a cylindrical part of the axle, and is kept there by a flange or rim, fixed behind the cone *c*. Several strong pins *f, f*, are cast into the back part of the box; which pins, when the wheel is attached, pass through corresponding holes in the collar *d*; and nuts being screwed on to the end of the pins *f*, behind the collar, keep the wheel securely attached to the axle. The screw-cap *g*, is then inserted into the recess *h*, at the outer part of the box, its conical end and small tube *i*, passing into the recess *k*, in the end of the axle.

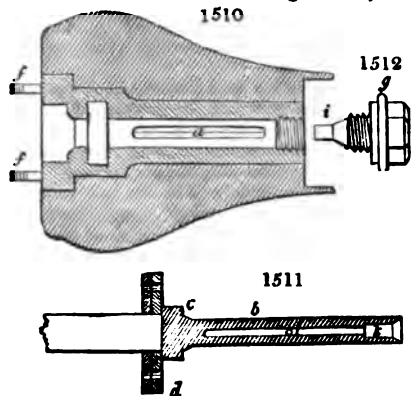
The parts being thus connected, the oil contained within the cap *g*, will flow through the small tube *i*, in its end, into the recess of cylindrical channel *l*, within the axle, and will thence pass through a small hole in the side of the axle, into the cylindrical recess *a*, of the box; and then lodging in the groove and other cavities within the box, will lubricate the axle as the wheel goes round. There is also a small groove cut on the outside of the axle, for conducting the oil, in order that it may be more equally distributed over the surface and the bearings.

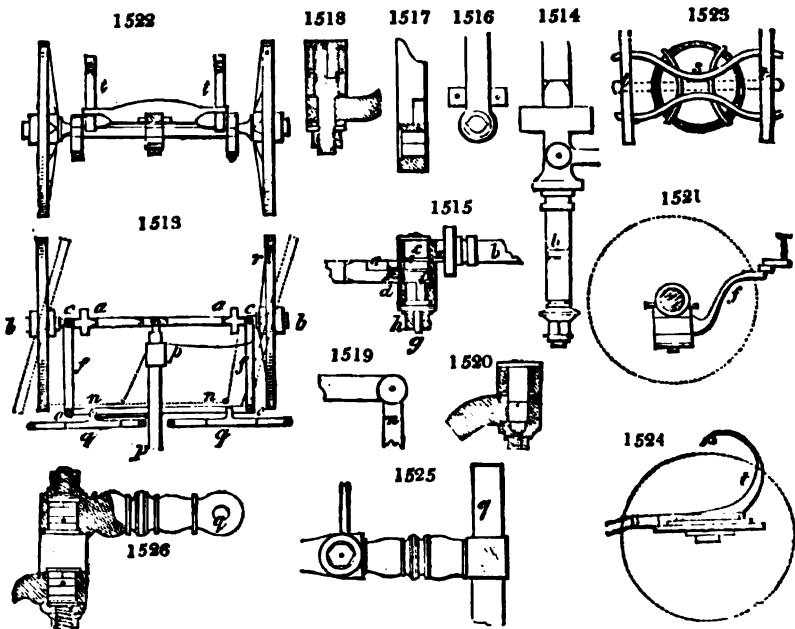
This construction of the box and axle, as far as the lubrication goes, may be applied to the axles of wheels in general; but that part of the invention which is designed to give greater security in the attachment of the wheel to the carriage applies particularly to mail axles.

Mr. William Mason's patent invention for wheel carriages, of August, 1831, will be understood by reference to the annexed figures. Fig. 1513. is a plan showing the four-axletree bed *a, a*, of a four-wheeled carriage, to which the axletrees *b, b*, are jointed at each end; fig. 1514. is an enlarged plan; and fig. 1515. an elevation, or side view of one end of the said fore-axletree bed,

having a Collinge's axletree jointed to the axletree bed, by means of the cylindrical pin or bolt *e*, which passes through and turns in a cylindrical hole *d*, formed at the end of the axletree bed, shown also in the plan view, fig. 1516., and section, fig. 1517.

The axletree *b*, is firmly united with the upper end *e*, of the pin or bolt *c*; and to the lower end of it, which is squared, the guide piece *f*, is also fitted, and secured by the screw *g*, and cap or nut *h*, seen in fig. 1515., and in section in fig. 1518. There are leather washers *i, i*, let into recesses made to receive them in the parts *a, b*, and *f*, the intent of





which is to prevent the oil from escaping that is introduced through the central perpendicular hole, seen in *fig. 1518.*, which hole is closed by means of a screw inserted into it. The oil is diffused, or spread over the surface of the cylinder *c*, by means of a side branch leading from the bottom of the hole into a groove formed around the cylinder, and also by means of two longitudinal gaps or cavities made within the hole, as shown in *figs. 1516.* and *1517.* The guide piece *f*, is affixed at right angles with the axle-tree *b*, as shown in *fig. 1514.*, and turns freely and steadily in the cylindrical hole *d*, made to receive one end of the iron fore-axletree bed *a*. In like manner, the opposite fore axletree *b*, *fig. 1513.*, is jointed to the other end of the iron fore-axletree bed. The outer ends of the guide pieces *f, f*, are jointed to the splinter-bar *n*, *fig. 1517*, as follows: — *Fig. 1519.* is a plan, and *fig. 1520.* a section of the joint *o*, in *fig. 1513.*, shown on an enlarged scale; a cylindrical pin or bolt *e*, is firmly secured in the splinter-bar, and round the lower part of the said pin or bolt the guide piece *f*, turns, and is made fast in its place by the screw *g*, and screwed nut *h*.

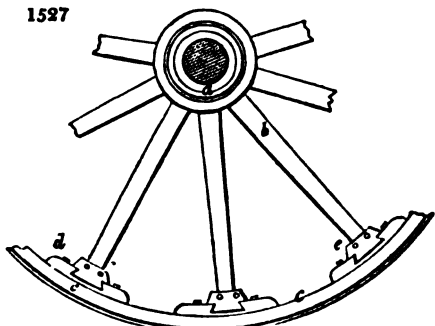
Oil is conveyed to the lower part of the cylindrical pin *c*, in a similar manner to that already described, and two leather washers are likewise furnished, to prevent its escape. The connecting joint at the opposite end of the splinter bar *n*, is constructed in a similar manner. The futchel or socket *p, p*, for the pole of the carriage, must also be jointed to the middle of the fore-axletree bed and splinter-bar, in a similar manner. The swingletrees *q, q*, *fig. 1513.*, are likewise jointed in the same way to the splinter-bar. *Fig. 1521.* is a side view of these parts. The fore-wheels of the carriage, *fig. 1513.*, are furnished with cast iron boxes, as usual. The dotted lines show the action of the pole *p, p*, upon the splinter-bar *n*, and as communicated through the latter to the guide pieces *f, f*, connected with the axletrees *b, b*, so as to lock the wheels *r, r*, as shown in that figure.

The axletree may be incased in the woodwork of the fore-bed of the carriage, as usual, and as shown by dotted lines in the back end view thereof, *fig. 1522.*; and the framing *s*, *fig. 1523.*, may be affixed firmly upon the said woodwork, in any fit and proper manner, as well as the fore-springs *t, t*, shown in *figs. 1522.* and *1523.*, and likewise in the side view, *fig. 1524.* In certain cases it may be desirable to fix the cylindrical pin or bolt *e*, firmly in the splinter-bar *n*, in the manner shown in *figs. 1525.* and *1526.*; the swingletrees *q, q*, and guide pieces *f, f*, turning freely above and below upon the said pin or bolt, and secured in their places thereon by screws and screwed nuts, oil being also supplied through holes formed in both ends of the said pin or bolt, and leather washers provided, as in the above-described instances.

Mr. Gibbs, engineer, and Mr. Chaplin, coach-maker obtained a patent, in 1832, for the construction of a four-wheeled carriage which shall be enabled to turn within a

small compass, by throwing the axles of all the four wheels simultaneously into different positions. They effect this object by mounting each wheel upon a separate jointed axle, and by connecting the free ends of the four axles by jointed rods or chains, with the pole and splinter-bar in front of the carriage.

1527



To fix the ends of the spokes of wheels to the felloe or rim, with greater security than had been effected by previous methods is the object of a contrivance for which William Howard obtained a patent, in February, 1830. *Fig. 1527.* shows a portion of a wheel constructed on this new method; *a*, is the nave, of wood; *b, b, b*, wooden spokes, inserted into the nave in the usual way; *c, c*, is the rim or felloe, in-

tended to be formed by one entire circle of wrought iron; *d, d*, and *e, e*, are the shoes or blocks, of cast iron, for receiving the ends of the spokes, which are secured by bolts to the rim on the inner circumference. The cap of the block *d*, is removed, for the purpose of showing the internal form of the block; *e, e*, have their caps fixed on, as they would appear when the spokes are fitted in. One of the caps or shoes is shown detached, upon a larger scale, at *fig. 1528.*, by which it will be perceived that the end

1528



of the spoke is introduced into the shoe on the side. It is proposed that the end of the spoke shall not reach quite to the end of the block, and that it shall be made tight by a wedge driven in. The wedge piece is to be of wood, as *fig. 1529.*, with a small slip of iron within it; and a hole is perforated in the

back of the block or shoe, for the wedge to be driven through. When this is done, the ends of the spokes become confined and tight; and the projecting extremities of the

1529



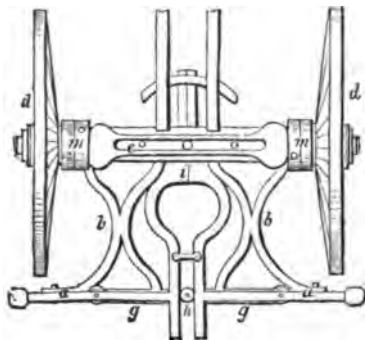
wedges being cut off, the caps are then attached on the face of the block, as at *e, e*, by pins riveted at their ends, which secures the spokes, and renders it impossible for them to be loosened by the vibrations as the wheel passes

over the ground. One important use of the wedges, is to correct the eccentric figure of the wheel, which may be readily forced out in any part that may be out of the true form, by driving the wedge up further; and this, it is considered, will be a very important advantage, as the nearer a wheel can be brought to a true circle, the easier it will run upon the road. The periphery of the wheel is to be protected by a tire, which may be put on in pieces, and bolted through the felloe; or it may be made in one ring, and attached, while hot, in the usual way.

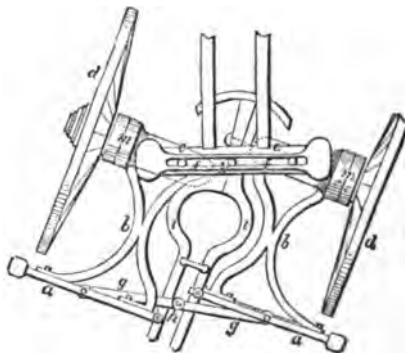
Mr. Reedhead's patent improvements in the construction of carriages, are represented in the following figures. They were specified in July, 1833.

Fig. 1530. is a plan or horizontal view of the fore part of a carriage, intended to be drawn by horses, showing the fore wheels in their position when running in a straight course; *fig. 1531.* is a similar view, showing the wheels as locked, when in the act of

1530



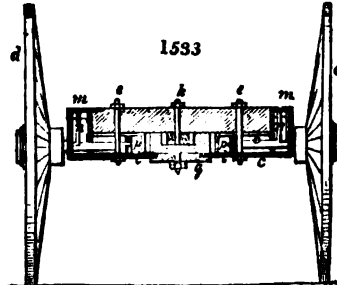
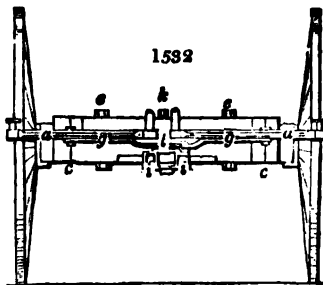
1531



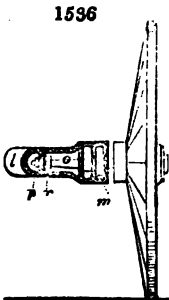
turning; *fig. 1532.* is a front end elevation of the same; *fig. 1533.* is a section taken through the centre of the fore axletree; and *fig. 1534.* is a side elevation of the general

appearance of a stage-coach, with the improvements appended: *a, a*, are two splinter-bars, with their roller bolts, for connecting the traces of the harness; these splinter-bars are attached, by the bent irons *b, b*, to two short axletrees or axle-boxes *c, c*, which carry the axles of the fore wheels *d, d*, and turn upon vertical pins or bolts *e, e*, passed through the fore axletree *f*, the splinter-bars and axle-boxes being mounted so as to move parallel to each other, the latter partaking of any motion given to the splinter-bars by the horses in drawing the carriage forward, and thereby producing the locking of the wheels, as shown in *fig. 1531.*; and in order that the two wheels, and their axles and axle-boxes, together with the splinter-bars *a, a*, may move simultaneously, the latter are connected by pivots to the end of the links or levers *g, g*, which are attached to the arms *t, t*, which receive the pole of the coach by a hinge-joint or pin *k*; the arms *i, i*, turning on a vertical fulcrum-pin *h*, passed through the main axletree *f*, as the pole *i* is moved from one side to the other.

The axles *o, o*, are firmly fixed into the nave of the wheels, as represented in the side view of a wheel detached, at *fig. 1536.*, the axles being mounted so as to revolve within their boxes in the following manner:—The axle-boxes, which answer the purpose of short axletrees, are formed of iron, and consist of one main or bottom plate *l*, seen best in *figs. 1536.* and *1535.*; upon this bottom plate is formed the chamber *m, m*, carrying the two anti-friction rollers *n, n*, which turn on short axles passed through the sides and partition at the upper part of the chambers. These anti-friction rollers bear upon the cylindrical parts of the axle *o*, of each wheel, and support the weight of the coach; *p*, is a bearing firmly secured in the axle-box to the plate *l*, for the end of the axle *o*, to run

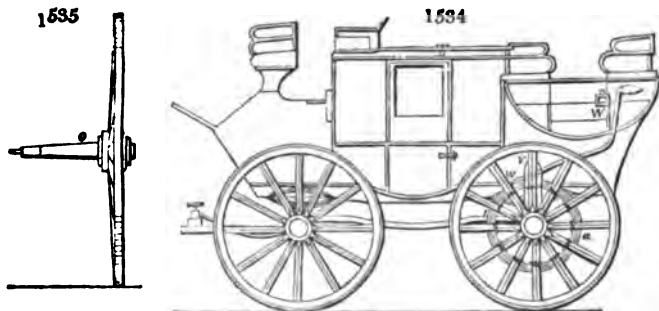


in, the axle being confined in its proper situation by a collar and screw-nut on its end; *e, e*, is the vertical pin or bolt before mentioned, upon which the axle-bar turns when the wheels are locking, which bolt is enlarged within the box, and has an eye for the axle to pass through, being firmly secured to the plate *l*, and also to the sides of the box. *Fig. 1536.* is a plan or horizontal view of an axle and its box, belonging to one of the



fore wheels; a piece *g*, is fixed to the under side of the main axletree, which supports the ends of the plates *l*, and thereby relieves the pins *e, e*, of the strain they would otherwise have to withstand. The axles of the hind wheels are mounted upon similar plates *l, l*, with bearings and chambers with anti-friction rollers; but as these are not required to lock, the plates, *l, l*, are fixed on to the under side of the hind axle-tree by screw-nuts; there are small openings or doors, which can be removed for the purpose of unscrewing the nuts and collars of the bearings *p*, when the wheel is required to be taken off the carriage, when the axle can be withdrawn from the boxes. If it should be thought necessary, other chambers with friction rollers may be placed on the under side of the plate *l*, to bear up the end of the axles, and relieve the bearing *p*. In order to stop or impede the progress of a carriage in passing down hills, there is a grooved friction or brake wheel *t*, fixed, by clamps or otherwise, on to the spokes of one of the hind wheels; *u*, is a brake-band or spring, of metal, encircling the friction wheel, one end of which band is fixed into the standard *v*, upon the hind axletree, and the other end connected by a joint to the shorter end of the lever *w*, which has its fulcrum in the standard *v*; this lever extends up to the hind seat of the coach, as shown in *fig. 1534.*, and is intended to be under the command of the guard or passengers of the coach, and when descending a hill, or on occasion of the horses running away, the longer end of the lever is to be depressed, which will raise the shorter end, and, consequently, bring the band or spring *u*, in contact with the surface of the friction wheel, and thereby

retard its revolution, and prevent the coach travelling too fast; or, instead of attaching the friction brake to the hind wheel, as represented in *fig. 1534.*, it may be adapted to



the fore wheels, and the end of the lever brought up to the side of the foot-board, or under it, and within command of the coachman, the standard which carries the fulcrum being made to move upon a pivot, to accommodate the locking of the wheels. It will be observed, that by these improved constructions of the carriage and mode of locking, the patentee is enabled to use much larger fore wheels than in common, and that the splinter-bars will always be in the position of right angles with the track or way of the horses in drawing the carriage, by which they are much relieved, and always pull in a direct and equal manner.

A manifest defect in all four-wheeled carriages, involving vast superfluous friction, is the small size of the front wheels; a defect which has existed ever since Walter Rippon made "the first hollow turning coach with pillars and arches for her majesty Queen Mary, being then her servant," until the railroad era, when our engineers remedied the defect by equalizing the wheels, at the expense of another defect—sacrificing the power of turning, and thus producing great lateral frictions, whence a train of evil consequences result:—necessarily increased strength, and consequently increased weight of the carriages; increased power and weight of the engine to draw them, and overcome the friction; and, of course, increased strength of rails, and greater solidity of railway.

These defects are at last remedied by an invention patented by Mr. William Adams, author of a work entitled "English Pleasure Carriages." Instead of placing the perch-bolt, or turning centre, as is commonly done, over the front axle, he places it at a convenient distance between the front and hind axles; so that when turning the carriage the front wheels, instead of turning beneath the body, as is common, turn outside of it, and the driver's seat turns with them; thus giving him a perfect command over his horses in all positions, instead of the usual dangerous plan, which renders a driver liable to be pulled off his box by a restive horse, when in the act of turning. A carriage constructed on Mr. Adams' plan may also be driven round a corner at full speed, without any risk of overturning, as the weight is equally poised on the axles in all positions. It is well known that the oversetting of stage coaches usually takes place when turning a corner, the momentum urging the vehicle in a right line, while the horses are pulling at an angle. By the new arrangement the front wheels may be made equal to the hind ones, or of any desirable height, and at the same time the body may be kept as low as may be thought convenient, even almost close to the ground, if desired. Thus two important objects, hitherto deemed incompatible, are combined—high wheels and a low centre of gravity. These carriages are therefore essentially safety carriages, while the friction is reduced to a minimum. The principle, in its various modifications, is applicable to every variety of carriage, both those of the simply useful kind, and those where beauty of form and colour are prime requisites.

Another most important part of Mr. Adams' invention is his new mode of spring suspension; applying the principle of the bow and string, for the first time, to obviate the effects of concussion in wheel carriages. All the springs hitherto in use for wheel carriages have been friction springs, composed of long sliding surfaces, uncertain in their action, and liable to quick destruction by rust. But Mr. Adams' springs are essentially elastic, being formed of single plates abutting endways, so that all friction is removed, and they can be hermetically sealed within paint to prevent their corrosion. He has various modes of applying the bow, either single or double, above or below the axle; but one most important feature is, that the axle being attached to the flexible cords or braces, the concussion which affects the wheels, either laterally, vertically, or in the line

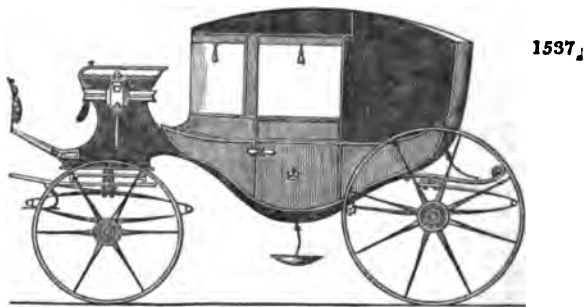
of progress, is perfectly intercepted, without the unpleasant oscillation experienced in carriages where the same purpose is accomplished by the use of the curved or C spring. Mr. Adams' brace being, at the same time, a non-conductor of sound, the rattling of the wheels does not annoy the rider as in ordinary carriages. His springs are equally applicable to vehicles with two and four wheels.

The advantages of these carriages may be thus summed up:—A great diminution of the total weight; a diminution of resistance in draught equal to about one-third; increase of safety to the riders; increased durability of the vehicle; absence of noise and vibration; absence of oscillation.

To these qualities, so desirable to all, and especially those of delicate nervous temperament, may be added—greater economy, both in the first cost and maintenance.

The *whirling* public so blindly follows fashionable caprice in the choice of a carriage, as to have hitherto paid too little attention to this fundamental improvement; but many intelligent individuals have fully verified its practical reality. Having inspected various forms of two-wheeled and four-wheeled carriages, in the patentee's premises in Drury Lane, I feel justified in recommending them as being constructed on the soundest mechanical principles; and have no doubt, that if reason be allowed to decide upon their merits, they will ere long be universally preferred by all who seek for easy-moving, safe, and comfortable vehicles.

Among the wheel carriages displayed in the Exhibition one of the most remarkable was the *amempton* (*unblamable*), of E. Kesterton, Long Acre. It is a close double-seated carriage, which by a simple contrivance can be converted into a light, open, step-piece, barouche, adapted for summer and winter. *Fig. 1537.* represents the carriage closed, or



what is termed the *amempton*, which can be readily converted into a step-piece barouche. *Fig. 1538.* is the carriage thrown completely open, and constructed as an ordinary open



carriage, with a half head, which is raised and lowered in the usual manner, with a solid folding knee flap. The front portion of the *amempton* is formed of a framework with circular front glasses, and furnished with doors. The door glasses and front glasses are made to rise and fall at pleasure, and are furnished with silk spring curtains, the whole being surmounted or covered with a roof. This framework is secured to the head with a new kind of fastening; the door glasses when down are received into the lower part of the doors; the back, instead of being flat, is of a curved form.

WHETSLATE, is a massive mineral of a greenish-gray colour; feebly glimmering; fracture, slaty or splintery; fragments tabular; translucent on the edges; feels rather greasy; and has a spec. grav. of 2.722. It occurs in beds, in primitive and transition slates. Very fine varieties of whetstone are brought from Turkey, called *honestones*, which are in much esteem for sharpening steel instruments.

WHEY (*Petit lait*, Fr.; *Molken*, Germ.); is the greenish-gray liquor which exudes from the curd of milk. Scheele states, that when a pound of milk is mixed with a spoonful of proof spirit, and allowed to become sour, the whey filtered off, at the end of a month or a little more, is a good vinegar, devoid of lactic acid.

WHISKEY; is dilute alcohol, distilled from the fermented worts of malt or grains.

WHITE LEAD, *Carbonate of lead*, or *Ceruse*. (*Blanc de plomb*, Fr.; *Bleiwässa*, Germ.) This preparation is the only one in general use for painting wood and the plaster walls of apartments white. It mixes well with oil, without having its bright colour impaired, spreads easily under the brush, and gives a uniform coat to wood, stone, metal, &c. It is employed either alone, or with other pigments, to serve as their basis, and to give them body. This article has been long manufactured with much success at Klagenfurth in Carinthia, and its mode of preparation has been lately described with precision by Marcel de Serres. The great white-lead establishments at Krems, whence, though incorrectly, the term *white of Kremitz* became current, on the continent, have been abandoned.

1. The lead comes from Bleyberg; it is very pure, and particularly free from contamination with iron, a point essential to the beauty of its factitious carbonate. It is melted in ordinary pots of cast iron, and cast into sheets of varying thickness, according to the pleasure of the manufacturer. These sheets are made by pouring the melted lead upon an iron plate placed over the boiler; and whenever the surface of the metal begins to consolidate, the plate is slightly sloped to one side, so as to run off the still liquid metal, and leave a lead sheet of the desired thinness. It is then lifted off like a sheet of paper; and as the iron plate is cooled in water, several hundred weight of lead can be readily cast in a day. In certain white-lead works these sheets are one twenty-fourth of an inch thick; in others, half that quantity; in some, one of these sheets takes up the whole width of the conversion-box; in others, four sheets are employed. It is of consequence not to smooth down the faces of the leaden sheets; because a rough surface presents more points of contact, and is more readily attacked by acid vapours, than a polished one.

2. These plates are now placed so as to expose an extensive surface to the acid fumes, by folding each other over a square slip of wood. Being suspended by their middle, like a sheet of paper, they are arranged in wooden boxes, from 4½ to 5 feet long, 12 to 14 inches broad, and from 9 to 11 inches deep. The boxes are very substantially constructed; their joints being mortised; and whatever nails are used, being carefully covered. Their bottom is made tight with a coat of pitch about an inch thick. The mouths of the boxes are luted over with paper, in the works where fermenting horse-dung is employed as the means of procuring heat, to prevent the sulphuretted and phosphuretted hydrogen from injuring the purity of the white lead. In Carinthia it was formerly the practice, as also in Holland, to form the lead sheets into spiral rolls, and to place them so coiled up in the chests; but this plan is not to be recommended, because these rolls present obviously less surface to the action of the vapours, are apt to fall down into the liquid at the bottom, and thus to impair the whiteness of the lead. The lower edges of the sheets are suspended about two inches and a half from the bottom of the box; and they must not touch either one another or its sides for fear of obstructing the vapours in the first case, or of injuring the colour in the second. Before introducing the lead, a peculiar acid liquor is put into the box, which differs in different works. In some, the proportions are four quarts of vinegar, with four quarts of wine- lees; and in others, a mixture is made of 20 pounds of wine- lees, with 8½ pounds of vinegar, and a pound of carbonate of potash. It is evident that in the manufactories where no carbonate of potash is employed in the mixture, and no dung for heating the boxes, it is not necessary to lute them.

3. The mixture being poured into the boxes, and the sheets of lead suspended within them, they are carried into a stove-room, to receive the requisite heat for raising round the lead the corrosive vapours, and thus converting it into carbonate. This apartment is heated generally by stoves, is about 9 feet high, 30 feet long, and 24 feet wide, or of such a size as to receive about 90 boxes. It has only one door.

The heat should never be raised above 86° Fahr.; and it is usually kept up for 15 days, in which time the operation is, for the most part, completed. If the heat be too high, and the vapours too copious, the carbonic acid escapes in a great measure, and the metallic lead, less acted upon, affords a much smaller product.

When the process is well managed, as much carbonate of lead is obtained as there was employed of metal; or, for 300 pounds of lead, 300 of ceruse are procured, besides a certain quantity of metal after the crusts are removed, which is returned to the melting-pot. The mixture introduced into the boxes serves only once; and if carbonate of potash has been used, the residuary matter is sold to the hatters.

4. When the preceding operation is supposed to be complete, the sheets, being removed from the boxes, are found to have grown a quarter of an inch thick, though

previously not above a twelfth of that thickness. A few pretty large crystals of acetate of lead are sometimes observed on their edges. The plates are now shaken smartly, to cause the crust of carbonate of lead formed on their surfaces to fall off. This carbonate is put into large cisterns, and washed very clean. The cistern is of wood, most commonly of a square shape, and divided into from seven to nine compartments. These are of equal capacity, but unequal height, so that the liquid may be made to overflow from one to the other. Thereby, if the first chest is too full, it decants its excess into the second, and so on in succession. See RINSING MACHINE.

The water poured into the first chest passes successively into the others, a slight agitation being meanwhile kept up, and there deposits the white lead diffused in it proportionally, so that the deposit of the last compartment is the finest and lightest. After this washing, the white lead receives another, in large vats, where it is always kept under water. It is lastly lifted out in the state of a liquid paste, with wooden spoons, and laid on drying-tables to prepare it for the market.

The white lead of the last compartment is of the first quality, and is called on the continent silver white. It is employed in fine painting.

When white lead is mixed in equal quantities with ground sulphate of barytes, it is known in France and Germany by the name of Venice white. Another quality, adulterated with double its weight of sulphate of barytes, is styled *Hamburgh white*; and a fourth, having three parts of sulphate to one of white lead, gets the name of *Dutch white*. When the sulphate of barytes is very white, like that of the Tyrol, these mixtures are reckoned preferable for certain kinds of painting, as the barytes communicates opacity to the colour, and protects the lead from being speedily darkened by sulphureous smoke or vapours.

The high reputation of the white lead of *Krems* was by no means due to the barytes, for the first and whitest quality was mere carbonate of lead. The freedom from silver of the lead of *Villach*, a very rare circumstance, is one cause of the superiority of its carbonate; as well as the skilful and laborious manner in which it is washed, and separated from any adhering particle of metal or sulphuret.

In England, lead is converted into carbonate in the following way:—The metal is cast into the form of a network grating, in moulds about 15 inches long, and 4 or 5 broad. Several rows of these are placed over cylindrical glazed earthen pots, about 4 or 5 inches in diameter, containing some treacle-vinegar, which are then covered with straw; above these pots another range is piled, and so in succession, to a convenient height. The whole are imbedded in spent bark from the tan-pit, brought into a fermenting state by being mixed with some bark used in a previous process. The pots are left undisturbed under the influence of a fermenting temperature for eight or nine weeks. In the course of this time the lead gratings become, generally speaking, converted throughout into a solid carbonate, which when removed is levigated in a proper mill, and elutriated with abundance of pure water. The plan of inserting coils of sheet lead into earthenware pipkins containing vinegar, and imbedding the pile of pipkins in fermenting horsedung and litter, is now little used; because the coil is not uniformly acted on by the acid vapours, and the sulphuretted hydrogen evolved from the dung is apt to darken the white lead.

In the above processes, the conversion of lead into carbonate seems to be effected by keeping the metal immersed in a warm, humid atmosphere, loaded with carbonic and acetic acids; and hence a pure vinegar does not answer well; but one which is susceptible, by its spontaneous decomposition in these circumstances, of yielding carbonic acid. Such are tartar, wine- lees, molasses, &c.

Another process has lately been practised to a considerable extent in France, though it does not afford a white lead equal in body and opacity to the products of the preceding operations. M. Thenard first established the principle, and MM. Brechot and Leseur contrived the arrangements of this new method, which was subsequently executed on a great scale by MM. Roard and Brechot.

A subacetate of lead is formed by digesting a cold solution of uncrystallized acetate, over litharge, with frequent agitation. It is said that 65 pounds of purified pyrolignous acid, of specific gravity 1.056, require, for making a neutral acetate, 58 pounds of litharge; and hence, to form the subacetate, three times that quantity of base, or 174 pounds, must be used. The compound is diluted with water, as soon as it is formed, and being decanted off quite limpid, is exposed to a current of carbonic acid gas, which, uniting with the two extra proportions of oxide of lead in the subacetate, precipitates them in the form of a white carbonate, while the liquid becomes a faintly acidulous acetate. The carbonic acid may be extricated from chalk, or other compounds, or generated by combustion of charcoal, as at *Clichy*; but in the latter case, it must be transmitted through a solution of acetate of lead before being admitted into the subacetate, to deprive it of any particles of sulphuretted hydrogen. When the precipitation of the carbonate of lead is completed, and well settled down, the supernatant acetate is decanted off, and made to act

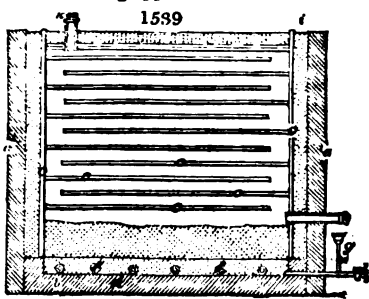
on another dose of litharge. The deposit being first rinsed with a little water, this washing is added to the acetate; after which the white lead is thoroughly elutriated. This repetition of the process may be indefinitely made; but there is always a small loss of acetate, which must be repaired, either directly or by adding some vinegar.

In order to obtain the finest white lead by the process with earthen pots containing vinegar buried in fermenting tan, and covered by a grating of lead, the metal should be so thin as to be entirely convertible into carbonate; for whenever any of it remains, it is apt to give a gray tint to the product: if the temperature of the fermenting mass is less than 90° Fahr., some particles of the metal will resist the action of the vinegar, and degrade the colour; and if it exceeds 122° , the white verges into yellow, in consequence of some carbonaceous compound being developed from the principles of the acetic acid. The dung and tan have been generally supposed to act in this process by supplying carbonic acid, the result of their fermentation; but it is now said that this explanation is inexact, because the best white lead can be obtained by the entire exclusion of air from the pots in which the carbonation of the metal is carried on. We are thence led to conclude that the lead is oxidized at the expense of the oxygen of the vinegar, and carbonated by the agency of its oxygen and carbon; the hydrogen of the acid being left to associate itself with the remaining oxygen and carbon, so as to constitute an ethereous compound: thus, supposing the three atoms of oxygen to form, with one of lead and one of carbon, an atom of carbonate, then the remaining three atoms of carbon and three of hydrogen would compose olefant gas.

It is customary on the continent to mould the white lead into conical loaves, before sending them into the market. This is done by stuffing well-drained white lead into unglazed earthen pots, of the requisite size and shape, and drying it to a solid mass, by exposing these pots in stove-rooms. The moulds being now inverted on tables, discharge their contents, which then receive a final desiccation; and are afterwards put up in pale-blue paper, to set off the white colour by contrast. Nothing in all the white-lead process is so injurious as this pot operation; a useless step, fortunately unknown in Great Britain. Neither greasing the skin, nor wearing thick gloves, can protect the operators from the diseases induced by the poisonous action of the white lead; and hence they must be soon sent off to some other department of the work.

It has been supposed that the differences observed between the ceruse of Clichy and the common kinds, depend on the greater compactness of the particles of the latter, produced by their slower aggregation; as also, according to M. Robiquet, on the former containing considerably less carbonic acid. See *infra*.

Mr. Ham proposed, in a patent dated June, 1826, to produce white lead with the aid of the following apparatus, *a, a*, (*fig. 1539*.)



are the side-walls of a stove-room constructed of bricks; *b*, is the floor of bricks laid in Roman cement; *c, c*, are the side-plates, between which and the walls a quantity of refuse tanner's bark, or other suitable vegetable matter, is to be introduced. The same material is to be put also into the lower part at *d* (upon a false bottom of grating?) The tan should rise to a considerable height, and have a series of strips of sheet lead *e, e, e*, placed upon it, which are kept apart by blocks or some other convenient means, with a space open at one end of the plates, for the passage of the vapours; but above the upper plates, boards are placed, and covered with tan, to confine them there. In the lower part of the chamber, coils of steam-pipe *f, f*, are laid in different directions to distribute heat; *g*, is a funnel-pipe, to conduct vinegar into the lower part of the vessel; and *h*, is a cock to draw it off, when the operation is suspended. The acid vapours raised by the heat pass up through the spent bark, and on coming into contact with the sheets of lead, corrode them. The quantity of acid liquor should not be in excess; a point to be ascertained by means of the small tube *i*, at top, which is intended for testing it by the tongue. *k*, is a tube for inserting a thermometer, to watch the temperature, which should not exceed 170° Fahr. I am not aware of what success has attended this patented arrangement. The heat prescribed is far too great.

A magnificent factory has been recently erected at West Bromwich, near Birmingham, to work a patent lately granted to Messrs. Gossage and Benson, for making white lead by mixing a small quantity of acetate of lead in solution with slightly damped litharge, contained in a long stone trough, and passing over the surface of the trough currents of hot carbonic acid, while its contents are powerfully stirred up by a travelling-wheel mechanism. The product is afterwards ground and elutriated, as usual.

The carbonic acid gas is produced from the combustion of coke. I am told that 40 tons of excellent white lead are made weekly by these chemico-mechanical operations. The factory has since proved abortive.

Messrs. Button and Dyer obtained a patent a few years ago, for making white lead by transmitting a current of purified carbonic acid gas, from the combustion of coke, through a mixture of litharge and nitrate of lead, diffused and dissolved in water, which is kept in constant agitation and ebullition by steam introduced through a perforated coil of pipes at the bottom of the tub. The carbonate of lead is formed here upon the principle of Thenard's old process with the subacetate; for the nitrate of lead forms with the litharge a subnitrate, which is forthwith transformed into carbonate and neutral nitrate, by the agency of the carbonic acid gas. I have discovered that all sorts of white lead produced by precipitation from a liquid, are in a semi-crystalline condition; appear, therefore, semi-transparent, when viewed in the microscope; and do not cover so well as white lead made by the process of vinegar and tan, in which the lead has remained always solid during its transition from the blue to the white state; and hence consists of opaque particles.

A patent was obtained, in December, 1833, by John Baptiste Constantine Torassa, and others, for making white lead by agitating the granulated metal, or shot, in trays or barrels, along with water, and exposing the mixture of lead-dust and water to the air, to be oxidized and carbonated. It is said that upwards of 100,000*l*. have been expended at Chelsea, by a joint-stock company, in a factory constructed for executing the preceding most operose and defective process; which has been, many years ago, tried without success in Germany. I am convinced that the whole of these recent projects for preparing white lead are inferior in economy, and quality of produce, to the old Dutch process, which may be so arranged as to convert sheets of blue lead thoroughly into the best white lead, within the space of 12 days, at less expense of labour than by any other plan.

White lead, as obtained by precipitation from the acetate, subacetate, and subnitrate, is a true carbonate of the metal, consisting of one prime equivalent of lead 104, one of oxygen 8, and one of carbonic acid 22; whose sum is 134, the atomic weight of the compound; or, of lead, 77·6; oxygen, 6; carbonic acid, 16·4; in 100 parts. It has been supposed, by some authors, that the denser and better-covering white lead of Krems and Holland is a kind of subcarbonate, containing only 9 per cent. of carbonic acid; but this view of the subject does not accord with my researches.

Mr. Thomas Richardson, of Newcastle, obtained a patent in December, 1839, for a preparation of sulphate of lead, applicable to some of the purposes to which the carbonate is applied. His plan is to put 56 pounds of flake litharge into a tub, to mix it with one pound of acetic acid (and water) of specific gravity 1·046, and to agitate the mixture till the oxide of lead becomes an acetate. But whenever this change is partially effected, he pours into the tub, through a pipe, sulphuric acid of specific gravity 1·5975, at the rate of about 1 pound per minute, until a sufficient quantity of sulphuric acid has been added to convert all the lead into a sulphate; being about 20 parts of acid to 112 of the litharge. The sulphate is afterwards washed and dried in stoves for the market. I have examined the particles of this white lead with a good achromatic microscope, and found them to be semi-crystalline, and semi-transparent, like all the varieties of carbonate precipitated from saline solutions of the metal.

Mr. Leigh, surgeon in Manchester, prepares his patent white lead, by precipitating a carbonate from a solution of the chloride of the metal by means of carbonate of ammonia. On this process, in a commercial point of view, no remarks need be made. In Liebig and Woehler's *Annalen* for May, 1843, Chr. Link has communicated his investigation of two sorts of lead, prepared in the Dutch way, by the slow action of vinegar and carbonic acid upon metallic lead, under the heat of fermenting horse-dung. The one sort was manufactured by Sprenger, the other by Klagenfurth of Krems. He also examined three specimens of the Offenbach white lead. They all agreed in composition; affording 11·29 per cent. of carbonic acid, and 2·23 of water; corresponding to the formula, $2(\text{PbO}, \text{CO}_2) + \text{PbO}, \text{H}_2\text{O}$; that is, in words, 2 atoms of carbonate of lead with one atom of oxide and 1 atom of water; in round numbers, thus, $2 \times 134 + 112 + 9$.

Mulder observed specimens of white lead, of different atomic proportions of carbonate, oxide, and water from the above, and discovered that the quality improved as the carbonate increased. The white lead by the Dutch process, as made by Messrs. Blackett of Newcastle, is certainly superior as a covering oil pigment to all others. Its particles are amorphous and opaque.

A patent was granted to Mr. Hugh Lee Pattinson in September, 1841, for improvements in the manufacture of white lead, &c. This invention consists in dissolving carbonate of magnesia in water impregnated with carbonic acid gas, by acting upon magnesian limestone, or other earthy substances containing magnesia in a soluble form, or upon

rough hydrate of magnesia in the mode hereafter described, and in applying this solution to the manufacture of magnesia and its salts, and the precipitation of carbonate of lead from any of the soluble salts of lead, but particularly the chloride of lead; in which latter case the carbonate of lead, so precipitated, is triturated with a solution of caustic potash or soda, by which a small quantity of chloride of lead contained in it is converted into hydrated oxide of lead, and the whole rendered similar in composition to the best white lead of commerce. The manner in which these improvements are carried into effect is thus described by the patentee:— I take magnesian limestone, which is well known to be a mixture of carbonate of lime and carbonate of magnesia in proportions varying at different localities; and on this account I am careful to procure it from places where the stone is rich in magnesia. This I reduce to powder and sift it through a sieve of forty or fifty apertures to the linear inch. I then heat it red-hot, in an iron retort or reverberatory furnace, for two or three hours, when, the carbonic acid being expelled from the carbonate of magnesia, but not from the carbonate of lime, I withdraw the whole from the retort or furnace, and suffer it to cool. The magnesia contained in the limestone is now soluble in water impregnated with carbonic acid gas, and to dissolve it I proceed as follows:— I am provided with an iron cylinder, lined with lead, which may be of any convenient size, say 4 ft. long by $2\frac{1}{2}$ ft. in diameter; it is furnished with a safety valve and an agitator, which latter may be an axis in the centre of the cylinder, with arms reaching nearly to the circumference, all made of iron and covered with lead. The cylinder is placed horizontally, and one extremity of this axis is supported within it by a proper carriage, the other extremity being prolonged and passing through a stuffing-box at the other end of the cylinder, so that the agitator may be turned round by applying manual or other power to its projecting end. A pipe, leading from a force-pump, is connected with the under side of the cylinder, through which carbonic acid gas may be forced from a gasometer in communication with the pump, and a mercurial gauge is attached, to show at all times the amount of pressure within the cylinder, independently of the safety-valve. Into a cylinder of the size given I introduce from 100 to 120 lbs. of the calcined limestone with a quantity of pure water, nearly filling the cylinder; I then pump in carbonic acid gas, constantly turning the agitator, and forcing in more and more gas, till absorption ceases, under a pressure of five atmospheres. I suffer it to stand in this condition three or four hours, and then run off the contents of the cylinder into a cistern, and allow it to settle. The clear liquor is now a solution of carbonate of magnesia in water impregnated with carbonic acid gas, or, as I shall hereafter call it, a solution of bicarbonate of magnesia, having a specific gravity of about 1.028, and containing about 1600 grains of carbonate of magnesia to the imperial gallon.

I consider it the best mode of obtaining a solution of bicarbonate of magnesia from magnesian limestone, to operate upon the limestone after being calcined at a red heat in the way described; but the process may be varied by using in the cylinder the mixed hydrates of lime and magnesia, obtained by completely burning magnesian limestone in a kiln, as commonly practised, and slaking it with water in the usual manner: or, to lessen the expenditure of carbonic acid gas, the mixed hydrates may be exposed to the air a few weeks till the lime has become less caustic by the absorption of carbonic acid from the atmosphere. Or the mixed hydrates may be treated with water, as practised by some manufacturers of Epsom salts, till the lime is wholly or principally removed; after which the residual rough hydrate of magnesia may be acted upon in the cylinder, as described; or hydrate of magnesia may be prepared for solution in the cylinder, by dissolving magnesian limestone in hydrochloric acid, and treating the solution, or a solution of chloride of magnesium, obtained from sea-water by salt-makers in the form of bittern, with its equivalent quantity of hydrate of lime, or of the mixed hydrates of lime and magnesia, obtained by completely burning magnesian limestone, slaking it as above. When I use this solution of bicarbonate of magnesia for the purpose of preparing magnesia and its salts, I evaporate it to dryness, by which a pure carbonate of magnesia is at once obtained, without the necessity of using a carbonated alkali, as in the whole process; and from this I prepare pure magnesia by calcination in the usual manner; or, instead of boiling to dryness, I merely heat the solution for some time to the boiling point, by which the excess of carbonic acid is partly driven off, and pure carbonate of magnesia is precipitated, which may then be collected, and dried in the same way as if precipitated by a carbonated alkali. If I require sulphate of magnesia, I neutralise the solution of bicarbonate of magnesia with sulphuric acid, boil down, and crystallise; or I mix the solution with its equivalent quantity of sulphate of iron, dissolved in water, heated to the boiling point, and then suffer the precipitated carbonate of iron to subside; after which I decant the clear solution of sulphate of magnesia, boil down, and crystallise as before. When using this solution of bicarbonate of magnesia for the purpose of preparing carbonate of lead, I make a saturated solution of chloride of lead in water, which at the temperature of 50° or 60° Fahr., has a specific

gravity of about 1.008, and consists of 1 part of chloride of lead dissolved in 126 parts of water. I then mix the two solutions together, when carbonate of lead is immediately precipitated; but in this operation I find it necessary to use certain precautions, otherwise a considerable quantity of chloride of lead is carried down along with the carbonate. These precautions are, first, to use an excess of the solution of magnesia, and secondly, to mix the two solutions together as rapidly as possible. As to the first, when using a magnesian solution containing 1600 grs. of carbonate of magnesia, per imperial gallon, with a solution of chloride of lead saturated at 55° or 60° Fahr., 1 measure of the former to $\frac{3}{4}$ of the latter is a proper proportion; in which case there is an excess of carbonate of magnesia employed, amounting to about an eighth of the total quantity contained in the solution. When either one or both the solutions vary in strength, the proportions in which they are to be mixed must be determined by preliminary trials. It is not, however, necessary to be very exact, provided there is always an excess of carbonate of magnesia amounting to from one-eighth to one-twelfth of the total quantity employed. If the excess is greater than one-eighth, no injury will result, except the unnecessary expenditure of the magnesian solution. As to the second precaution, of mixing the two solutions rapidly together, it may be accomplished variously; but I have found it a good method to run them in two streams, properly regulated in quantity, into a small cistern, in which they are to be rapidly blended together by brisk stirring, before passing out, through a hole in the bottom, to a large cistern or tank, where the precipitate finally settles. The precipitate thus obtained is to be collected, washed and dried in the usual manner. It is a carbonate of lead, very nearly pure, and suitable for most purposes; but it always contains a small portion of chloride of lead, seldom less than from 1 to 2 per cent., the presence of which, even in so small a quantity, is somewhat injurious to the colour and body of the white lead. I decompose this chloride, and convert it into a hydrated oxide of lead by grinding the dry precipitate with a solution of caustic alkali, in a mill similar to the ordinary mill used in grinding white lead with oil, adding just so much of the lye as may be required to convert the precipitate into a soft paste. I allow this paste to lie a few days, after which, the chloride of lead being entirely, or almost entirely decomposed, I wash out the alkaline chloride formed by the reaction, and obtain a white lead, similar in composition to the best white lead of commerce. I prepare the caustic alkaline lye by boiling together, in a leaden vessel, for an hour or two, 1 part by weight of dry and recently-slacked lime, 2 parts of crystallised carbonate of soda (which, being cheaper than carbonate of potash, I prefer) and 8 parts of water. The clear and colourless caustic lye, obtained after subsidence, will have a specific gravity of about 1.090, and when drawn off from the sediment, must be kept in a close vessel for use.

As we have before hinted, the manufacture of white lead by the Dutch process is one the nature of which seems yet enveloped in considerable obscurity. So far as appearances go, the action would seem to consist; first, in the oxidation of metallic lead by the atmosphere, under the influence of the vapour of acetic acid; secondly, in the production of acetate of lead, by the combination of the oxide of lead with the acetic acid; and, thirdly, in the displacement of the acetic acid from its union with the oxide of lead, by the action of carbonic acid, and the consequent formation of white lead. But this in no way accounts for the fact, that, when acetate of lead is decomposed by carbonic acid, it is carbonate of lead, and not white lead, which is formed. Nor can we conceive how an acid like the acetic is capable of being wholly expelled from a metallic oxide by a quantity of another acid incapable of completely saturating the oxide. In other words, as white lead contains free or uncombined oxide of lead, how happens it that the free acetic acid does not remain united to this? We confess our inability to reconcile the facts of the case with the preceding hypothesis, and therefore pass on to another, in which we will assume that acetate of lead, but not the neutral acetate, is formed as we have already supposed. Now there are two subacetates; one composed of six atoms of oxide of lead to one atom of acetic acid; and the other consisting of three atoms of oxide of lead to one of acetic acid. We select, in preference, the former, as it is the one which forms naturally when acetic acid acts, at common temperatures, on an excess of oxide of lead. The composition of this salt is such, that, if we can conceive slow combustion to take place, or that its acetic acid combining with the oxygen of the air is resolved into water and carbonic acid, then the carbonic acid produced would be exactly sufficient to saturate four atoms of the oxide of lead, and leave a compound of the precise composition of white lead. On this view, the first action in a white lead stack would be the production of sex-basic acetate of lead; and the next would be the destruction of this by remacausis, and the formation of white lead.

The apparatus employed in the manufacture of white lead is extremely simple, and consists merely of certain large enclosures or spaces, called beds, in which the stacks are built up; together with the earthenware pots needed for holding the vinegar, and the

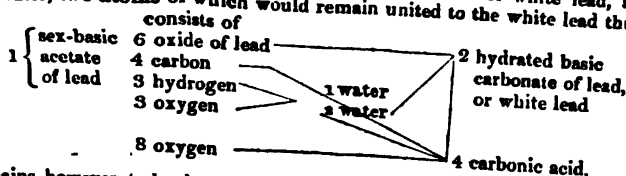
machinery used in casting the lead and grinding the white lead, so as to fit it for the market. The metallic lead was formerly used in the shape of sheets or coils, which were placed perpendicularly over the vinegar pots; but this practice has been almost everywhere abandoned, and at present the lead is generally cast into what are called "crates" or "grates," of about 9 inches square, and having the appearance of lattice-work; the object being to expose as large a surface as possible of metallic lead to the action of the vapour of the vinegar. The beds are of considerable size; and, in this respect, some diversity of opinion prevails amongst practical men; but it seems pretty certain that no advantage is gained when the area of a bed comes to exceed 300 square feet; and there are many reasons for believing, that, with beds of twice this area, the gain, in point of diminished labour, is much more than compensated for by the reduced produce in white lead. Nevertheless, each manufacturer seems to entertain an opinion of his own in respect to this matter; and there are even some pretensions to secrecy concerning it. In fact, everything depends upon the construction of the bed, for it is this which regulates the production of white lead; and, as a proof of the great importance connected with this circumstance, we may here mention, that, whilst one manufacturer has produced as much as 65 per cent. of corrosion during a long course of years, another in his immediate neighbourhood has never been able to exceed 52 per cent. The beds of the former are 16 feet square, whilst those of the latter are 19½ feet square; and, in dwelling upon the details of this operation, we shall find that theoretically, a bed may be too large, as the above practical fact indicates. Similarly it can be shown that a stack (which is merely a series of beds) may be too large; and experience has convinced us that a stack containing more than eight beds is to be condemned; and, as a general rule, six should be preferred, except where want of space renders a different line of manufacture indispensable.

In forming a stack, it is necessary to begin by laying, in the first instance, a bed of spent tanner's bark, 9 feet in thickness, over the surface of the bed; and upon this are placed the earthenware pots containing the vinegar. These are arranged, side by side, and filled to about one-third of their contents with vinegar, of a strength equal to 6 per cent. of anhydrous acetic acid. Upon these pots are placed the crates of lead, and over all a series of boards are arranged, which form a floor for the next layer of spent tan. Such an arrangement as we have described, is denominated "a bed," but there is this difference between the beds, viz., that the lowest or bottom bed has a bed of tan 3 feet in thickness, whereas but 1 foot is needed in the others. Having finished the lowest bed, 12 inches of spent tan are now placed upon the boards, and a similar arrangement of pots, crates, and boards, takes place, which constitutes the second bed; this is followed by a third, a fourth, and so on, until at last the uppermost bed is finished; when a layer of spent tan, 30 inches in thickness, is placed over the whole, and the operation may be said to commence. In six or eight days the tan begins to ferment and evolve heat; and this goes on increasing for some weeks, when it gradually diminishes, and at the end of about three months the whole has become cool, and the stack is fit to be taken down. When examined, the pots, which formerly contained vinegar, will now be found to be quite empty, or to hold a little water merely, but no acetic acid; the leaden crates will be discovered to have increased sensibly in bulk, to have become coated with a thick and dense incrustation of white lead, and in some places even to have become altogether converted into this substance; whilst the tan, having lost its fermentative quality, is now useless, except as fuel.

The successive beds constituting the entire stack are next carefully removed, so as to obtain the white lead with the least possible admixture of the tan; and as a portion of this substance always adheres to the crates, these are washed in a kind of wear or trough, by which the whole of the tan is thoroughly separated. When this is seen to be complete, the corroded part of the plate or "white lead" is detached from the uncorroded or "blue lead," by means of slight taps or blows with a mallet. The blue lead is weighed, and, for the most part, remelted and again cast into crates; whilst the white lead is first crushed, and afterwards ground in water into a fine powder, when it is collected by elutriation and deposition, and dried in stoves, a little below the boiling heat of water. Formerly this grinding was performed in the dry way, and much injury to the health of the workmen thus resulted; but, during the last 20 years, the wet mode of grinding has become general, and is greatly to be preferred.

The conversion of white lead into paint is a simple mechanical operation, though, as we have before remarked, it is followed by chemical results; for there can be no doubt that the surplus oxide in the white lead combines with part of the oil employed to form the paint, and gives rise to a true plaster or metallic soap. The proportions of oil and white lead vary with different manufacturers; nor does it much matter what these proportions are: the principal point is to obtain a thorough intermixture of the two ingredients; and this is done by grinding them together beneath heavy stones or "runners," for several hours, at the end of which time the mixture will be found homogeneous.

If we examine the process of white lead making with a view to discover its chemical peculiarities, we perceive at once that it presents no salient feature to guide our inquiry. The most probable explanation is certainly that before given, and which supposes the pre-existence of sex-basic acetate of lead. At the same time there are no experiments which prove that this substance is capable of undergoing the slow combustion requisite to complete the argument. But then this is precisely the question which now calls for remeasaris or combustion here hinted at. And presuming this to be correct, then one atom of the sex-basic acetate of lead and eight atoms of atmospheric oxygen, would unite as in the following diagram, and produce two atoms of white lead, and three atoms of water, two atoms of which would remain united to the white lead thus: —



It remains, however, to be demonstrated, whether this kind of sub-acetate of lead, and which is readily formed by boiling acetic acid with a large excess of litharge, can, under the influence of a gentle heat, become thus converted into white lead.

Connected with this subject is the fabrication of an article called the sub-chloride of lead, or oxychloride, which is now coming into use as a substitute for white lead. The oxychloride is so constituted, that, if for two atoms of carbonate of lead in white lead, we substitute two atoms of chloride of lead, the result will be the new compound, and which has been made the subject of a patent by Mr. H. Pattinson, of Newcastle-upon-Tyne. Now it is a very remarkable fact, and strongly corroborative of the views which we have here advanced, that the new paint "covers" equally well with the best white lead, just as its basic composition would indicate; and the probability is, that the oxide of lead contained in it unites to part of the oil of the paint, forming as before a metallic soap; whilst the chloride of lead remains interspersed in the mass, and communicates opacity and whiteness. An observation made, we believe, in the first instance by Dr. Ure, shows the correctness of such a conclusion; for, although, when alone, the oxychloride of lead be quite insoluble in water, yet, after admixture with oil, boiling water readily dissolves from the mass the chloride of lead, and leaves the oxide combined with the oil. This circumstance, which can be easily demonstrated, seems also to show, that a soluble salt, like the chloride. Experience, however, alone can decide the correctness of this assertion. — *Mr. Lewis Thompson.*

WICK (*Mèche*, Fr.; *Docht*, Germ.); is the spongy cord, usually made of soft spun cotton threads, which by capillary action draws up the oil in lamps, or the melted tallow or wax in candles, in small successive portions, to be burned. In common wax and tallow candles, the wick is formed of parallel threads; in the stearine candles, the wick is plaited upon the braiding machine, moistened with a very dilute sulphuric acid, and dried, whereby, as it burns, it falls to one side and consumes without requiring to be snuffed; in the patent candles of Mr. Palmer, one-tenth of the wick is first imbued with subnitrate of bismuth ground up with oil; the whole is then bound round in the manner called *gimping*; and of this wick, twice the length of the intended candle is twisted double round a rod, like the *caduceus of Mercury*. This rod with its coil being inserted in the axis of the candle mould, is to be enclosed by pouring in the melted tallow; and when the tallow is set, the rod is to be drawn out at top, leaving the wick in the candle. As this candle is burned, the ends of the double wick stand out sideways beyond the flame; and the bismuth attached to the cotton being acted on by the oxygen of the atmosphere, causes the wick to be completely consumed, and, therefore, saves the trouble of snuffing it.

WINDLING-MACHINE, is the English name of the dyer's reel, which he suspends horizontally, by the ends of its iron axis in bearings, over the edge of his vat, so that the line of the axis, being placed over the middle partition in the copper, will permit the piece of cloth which is wound upon the reel, to descend alternately into either compartment of the bath, according as it is turned by hand to the right or the left. For an excellent self-acting or mechanical wince, see DYEING.

WINDLASSES. (*Exhibition.*) John Gladstone, Jun. & Co., Liverpool, Manufacturers. Model of a ship's windlass purchase, for raising anchors, chain-cables, and other heavy weights on board ships, sufficient to ride the ship without the possibility of having the windlass upset. With this machine less than half the usual number of hands are required to weigh the anchor, &c. The ordinary ship's windlass is a spindle-shaped

beam, polygonal in transverse section, acting horizontally at right angles to a line bisecting the ship from stem to stern, and working in, and bearing upon, stanchions, called "knight-heads," strongly fixed to the ship's deck and deck-timbers immediately abaft the foremast. The use of the windlass is to raise or weigh the anchor, by means of the cable, which is made to take a turn round the windlass beam, whose spindle shape enables it to present itself at right angles to a line drawn from either hawsehole, under which the anchor may lie, for the ship is hove short upon her anchor by means of the more quickly moving, but less powerful capstan, before the windlass is called into action. The "purchase" of a windlass is the power applicable to work it, or rather the means provided, as the handspike levers in ordinary use, of applying the power of the men to turn the beam, and wind or hoist up the anchor by its cable. Nothing can exceed the simplicity or strength of the ordinary ship's windlass, having regard to the size and strength of the ship herself; but there is room for improvement in the power and in the speed of a windlass, and the means of doing the same work with fewer hands would be a great advantage.

WINE is the fermented juice of the grape. In the more southern states of Europe, the grapes, being more saccharine, afford a more abundant production of alcohol, and stronger wines, as exemplified in the best port, sherry, and madeira. The influence of solar heat upon the vines may, however, be mitigated by growing them to moderate heights on level ground, and by training them in festoons under the shelter of trees. In the more temperate climates, such as the district of Burgundy, the finer flavoured wines are produced; and there the vines are usually grown upon hilly slopes fronting the south, with more or less of an easterly or westerly direction, as on the Côte d'Or, at a distance from marshes, forests, and rivers, whose vapours might deteriorate the air. The plains of this district, even when possessing a similar or analogous soil, do not produce wines of so agreeable a flavour. The influence of temperature becomes very manifest in countries further north, where, in consequence of a few degrees of thermometric depression, the production of generous agreeable wine becomes impossible.

The land most favourable to the vine is light, easily permeable to water, but somewhat retentive by its composition; with a sandy subsoil, to allow the excess of moisture to drain readily off. Calcareous soils produce the highly esteemed wines of the Côte d'Or; a granitic debris forms the foundation of the lands where the Hermitage wines are grown; siliceous soil interspersed with flints furnishes the celebrated wines of Château-Neuf, Ferté, and La Gaude; schistose districts afford also good wine, as that called *la Malgue*. Thus we see that lands differing in chemical composition, but possessed of the proper physical qualities, may produce most agreeable wines; and so also may lands of like chemical and physical constitution produce various kinds of wine, according to their varied exposure. As a striking example of these effects, we may adduce the slopes of the hills which grow the wines of Montrachet. The insulated part towards the top furnishes the wine called *Chevalier Montrachet*, which is less esteemed, and sells at a much lower price, than the delicious wine grown on the middle height, called *true Montrachet*. Beneath this district, and in the surrounding plains, the vines afford a far inferior article, called *bastard Montrachet*. The opposite side of the hills produces very indifferent wine. Similar differences, in a greater or less degree, are observable relatively to the districts which grow the Pomard, Volnay, Beaune, Nuits, Vougeot, Chambertin, Romanée, &c. Every where it is found, that the reverse side of the hill, the summit and the plain, although generally consisting of like soils, afford inferior wine to the middle southern slopes.

Amelioration of the soil. — When the vine lands are too light or too dense, they may be modified, within certain limits, by introducing into them either argillaceous or siliceous matter. Marl is excellent for almost all grounds which are not previously too calcareous, being alike useful to open dense soils, and to render porous ones more retentive.

Manure. — For the vine, as well as all cultivated plants, a manure supplying azotized or animal nutriment may be used with great advantage, provided care be taken to ripen it by previous fermentation, so that it may not, by absorption in too crude a state, impart any disagreeable odour to the grape; as sometimes happens to the vines grown in the vicinity of great towns, like Paris, and near Argenteuil. There is a compost used in France, called *animalized black*, of which from $\frac{1}{4}$ to $\frac{1}{2}$ of a litre (old English quart) serves sufficiently to fertilize the root of one vine, when applied every year or two years. An excess of manure, in rainy seasons especially, has the effect of rendering the grapes large and insipid.

The ground is tilled at the same time as the manure is applied, towards the month of March; the plants are then dressed, and the props are inserted. The weakness of the plants renders this practice useful; but in some southern districts, the stem of the vine, when supported at a proper height, acquires after a while sufficient size and

strength to stand alone. The ends of the props or poles are either dipped in tar, or charred, to prevent their rotting. The bottom of the stem must be covered over with soil, after the spring rains have washed it down. The principal husbandry of the vineyard consists in digging or ploughing to destroy the weeds, and to expose the soil to the influence of the air, during the months of May, June, and occasionally in August.

The vintage, in the temperate provinces, generally takes place about the end of September; and it is always deteriorated whenever the fruit is not ripe enough before the 15th or 20th of October; for, in this case, not only is the must more acid, and less saccharine, but the atmospherical temperature is apt to fall so low during the nights, as to obstruct more or less its fermentation into wine. The grapes should be plucked in dry weather, at the interval of a few days after they are ripe; being usually gathered in baskets, and transported to the vats in dorsels, sufficiently tight to prevent the juice from running out. Whenever a layer about 14 or 15 inches thick has been spread on the bottom of the vat, the treading operation begins, which is usually repeated after macerating the grapes for some time, when an incipient fermentation has softened the texture of the skin and the interior cells. When the whole bruised grapes are collected in the vat, the juice, by means of a slight fermentation, reacts, through the acidity thus generated, upon the colouring-matter of the husks, and also upon the tannin contained in the stones and the fruit-stalks. The process of fermentation is suffered to proceed without any other precaution, except forcing down from time to time the pellicles and pedicles floated up by the carbonic acid to the top; but it would be less apt to become acetous, were the mouths of the vats covered. With this view, M. Seville Augur introduced with success his elastic bung in the manufacture of wine in the department of the Maine-et-Loire.

With whatever kind of apparatus the fermentation may have been regulated, as soon as it ceases to be tumultuous, and the wine is not sensibly saccharine or muddy, it must be racked off from the lees, by means of a spigot, and run into the ripening tuns. The marc being then gently squeezed in a press, affords a tolerably clear wine, which is distributed among the tuns in equal proportions; but the liquor obtained by stronger pressure is reserved for the casks of inferior wine.

In the south of France the fermentation sometimes proceeds too slowly, on account of the must being too saccharine; an accident which is best counteracted by maintaining a temperature of about 65° or 68° F., in the tun-room. When the must, on the other hand, is too thin, and deficient in sugar, it must be partially concentrated by rapid boiling, before the whole can be made to ferment into a good wine. By boiling up a part of the must for this purpose, the excess of ferment is at the same time destroyed. Should this concentration be inconvenient, a certain proportion of sugar must be introduced, immediately after racking it off.

The specific gravity of must varies with the richness and ripeness of the grapes which afford it; being in some cases so low as 1·0627, and in others so high as 1·283. This happens particularly in the south of France. In the district of the Necker in Germany, the specific gravity varies from 1·050 to 1·090; in Heidelberg, from 1·039 to 1·091; but it varies much in different years.

After the fermentation is complete, the vinous part consists of water, alcohol, a colouring-matter, a peculiar aromatic principle, a little undecomposed sugar, bitartrate and malate of potash, tartrate of lime, muriate of soda, and tannin; the latter substances being in small proportion.

It is known that a few green grapes are capable of spoiling a whole cask of wine, and therefore they are always allowed to become completely ripe, and even sometimes to undergo a species of slight fermentation, before being plucked, which completes the development of the saccharine principle. At other times the grapes are gathered whenever they are ripe, but are left for a few days on wicker-floors, to sweeten, before being pressed.

In general the whole vintage of the day is pressed in the evening, and the resulting must is received in separate vats. At the end usually of 6 or 8 hours, if the temperature be above 50° F., and if the grapes have not been too cold when plucked, a froth or scum is formed at the surface, which rapidly increases in thickness. After it acquires such a consistence as to crack in several places, it is taken off with a skimmer, and drained; and the thin liquor is returned to the vat. A few hours afterwards another coat of froth is formed, which is removed in like manner, and sometimes a third may be produced. The regular vinous fermentation now begins, characterised by air-bubbles rising up the sides of the staves, with a peculiar whizzing as they break at the surface. At this period all the remaining froth should be quickly skimmed off, and the clear subjacent must, be transferred into barrels, where it is left to ripen by a regular fermentation.

The white wines, which might be disposed to become stringy, from a deficient supply of tannin, may be preserved from this malady by a due addition of the footstalks of ripe

grapes. The tannin, while it tends to preserve the wines, renders them also more easy to clarify, by the addition of white of egg, or isinglass.

The white wines should be racked off as soon as the first frosts have made them clear, and at the latest by the end of the February moon. By thus separating the wine from the lees, we avoid, or render of little consequence, the fermentation which takes place on the return of spring, and which, if too brisk, would destroy all its sweetness, by decomposing the remaining portion of sugar.

The characteristic odour possessed by all wines, in a greater or less degree, is produced by a peculiar substance, which possesses the characters of an essential oil. As it is not volatile, it cannot be confounded with the aroma of wine. When large quantities of wine are distilled, an oily substance is obtained towards the end of the operation. This may also be procured from the wine lees which are deposited in the casks after the fermentation has commenced. It forms one 40,000th part of the wine; and consists of a peculiar new acid, and ether, each of which has been called the *œnanthic*. The acid is analogous to the fatty acids, and the ether is liquid, but insoluble in water. The acid is perfectly white when pure, of the consistence of butter at 60°, melts with a moderate heat, reddens litmus, and dissolves in caustic and carbonated alkalis, as well as in alcohol and ether. *œnanthic* ether is colourless, has an extremely strong smell of wine, which is almost intoxicating when inhaled, and a powerful disagreeable taste.—*Liebig and Pelouze*.

Sparkling wines.—In the manufacture of these, black grapes of the first quality are usually employed, especially those gathered upon the vine called by the French *noirien*, cultivated on the best exposures. As it is important, however, to prevent the colouring-matter of the skin from entering into the wine, the juice should be squeezed as gently and rapidly as possible. The liquor obtained by a second and third pressing is reserved for inferior wines, on account of the reddish tint which it acquires. The mare is then mixed with the grapes of the red-wine vats.

The above nearly colourless must is immediately poured into tuns or casks, till about three-fourths of their capacity are filled, when fermentation soon begins. This is allowed to continue under the control of the elastic bung, above mentioned, for about 15 days, and then three-fourths of the casks are filled up with wine from the rest. The casks are now closed by a bung secured with a piece of hoop iron nailed to two contiguous staves. The casks should be made of new wood, but not of oak—though old white wine casks are occasionally used.

In the month of January the clear wine is racked off, and is fined by a small quantity of isinglass dissolved in old wine of the same kind. Forty days afterwards a second fining is required. Sometimes a third may be useful, if the lees be considerable. In the month of May the clear wine is drawn off into bottles, taking care to add to each of them a small measure of what is called *liquor*, which is merely about 3 per cent. of a syrup made by dissolving sugar-candy in white wine. The bottles being filled, and their corks secured by packthread and wire, they are laid on their sides, in this month, with their mouths sloping downwards at an angle of about 20 degrees, in order that any sediment may fall into the neck. At the end of 8 or 10 days, the inclination of the bottles is increased, when they are slightly tapped, and placed in a vertical position; so that after the lees are all collected in the neck, the cork is partially removed for an instant, to allow the sediment to be expelled by the pressure of the gas. If the wine be still muddy in the bottles, along with a new dose of *liquor*, a small quantity of fining should be added to each, and the bottles should be placed again in the inverted position. At the end of two or three months, the sediment collected over the cork, is dexterously discharged; and if the wine be still deficient in transparency, the same process of fining must be repeated.

Sparkling wine (*vin mousseux*), prepared as above described, is fit for drinking usually at the end of 18 to 30 months, according to the state of the seasons. It is in Champagne that the lightest, most transparent, and most highly flavoured wines, have been hitherto made. The breakage of the bottles in these sparkling wines amounts frequently to 30 per cent., a circumstance which adds greatly to their cost of production.

Weak wines of bad growths ought to be consumed within 12 or 15 months after being manufactured; and should be kept meanwhile in cool cellars. White wines of middling strength ought to be kept in casks constantly full, and carefully excluded from contact of air, and the racking off should be done as quickly as possible. As the most of them are injured by too much fermentation, this process should be so regulated as always to leave a little sugar undecomposed. It is useful to counteract the absorption of oxygen, and the consequent tendency to acidity, by burning a sulphur match in the casks into which they are about to be run. This is done by hooking the match to a bent wire, kindling and suspending it within the cask through the bung-hole. Immediately on withdrawing the match, the cask should be corked, if the wine be not

ready for transfer. If the burning sulphur be extinguished on plunging it into the cask, it is a proof of the cask being unsound, and unfit for receiving the wine; in which case it should be well cleansed, first with lime-water, then with very dilute sulphuric acid, and lastly with boiling water.

Wine-cellars ought to be dry at bottom, floored with flags, have windows opening to the north, be so much sunk below the level of the adjoining ground as to possess a nearly uniform temperature in summer and winter; and be at such a distance from a frequented highway or street as not to suffer vibration from the motion of carriages.

Wines should be racked off in cool weather: the end of February being the fittest time for light wines. Strong wines are not racked off till they have stood a year or eighteen months upon the lees, to promote their slow or insensible fermentation. A siphon well managed serves better than a fauset to draw off wine clear from the sediment. White wines, before being bottled, should be fined with isinglass; red wines are usually fined with whites of eggs beat up into a froth, and mixed with two or three times their bulk of water. But some strong wines, which are a little harsh from excess of tannin, are fined with a little sheep or bullock's blood. Occasionally a small quantity of sweet glue is used for this purpose.

The following maladies of wines, are certain accidental deteriorations, to which remedies should be speedily applied.

La-pousse (pushing out of the cask), is the name given to a violent fermentative movement, which occasionally supervenes after the wine has been run off into the casks. If these have been tightly closed, the interior pressure may increase to such a degree as to burst the hoops, or cause the seams of the staves or ends to open. The elastic bungs already described, will prevent the bursting of the casks; but something must be done to repress the fermentation, lest it should destroy the whole of the sugar, and make the wine unpalatably harsh. One remedy is, to transfer the wine into a cask previously fumigated with burning sulphur; another is, to add to it about one thousandth part of sulphite of lime; and a third, and perhaps the safest, is to introduce half a pound of mustard-seed into each barrel. At any rate the wines should be fined whenever the movements are allayed, to remove the floating ferment which has been the cause of the mischief.

Turning sour. — The production of too much acid in a wine is a proof of its containing originally too little alcohol, of its being exposed too largely to the air, or to vibrations, or to too high a temperature in the cellar. The best thing to be done in this case is, to mix it with its bulk of a stronger wine in a less advanced state, to fine the mixture, to bottle it, and to consume it as soon as possible, for it will never prove a good keeping wine. This *distemper* in wines formerly gave rise to the very dangerous practice of adding litharge as a sweetener; whereby a quantity of acetate or sugar of lead was formed in the liquor, productive of the most deleterious consequences to those who drank of it. In France, the regulations of police, and the enlightened *surveillance* of the Council of Salubrity, have completely put down this gross abuse. The saturation of the acid by lime and other alkaline bases has generally a prejudicial effect, and injures more or less the vinous flavour and taste.

Ropiness or visciditv of wines. — The cause of this phenomenon, which renders wine unfit for drinking, was altogether unknown, till M. François, an apothecary of Nantes, demonstrated that it was owing to an azotised matter, analogous to *gliadine* (gluten); and in fact it is the white wines, especially those which contain the least tannin, which are subject to this malady. He also pointed out the proper remedy, in the addition of tannin under a rather agreeable form, namely, the bruised berries of the mountain-ash (*sorbier*), in a somewhat unripe state; of which one pound, well stirred in, is sufficient for a barrel. After agitation, the wine is to be left in repose for a day or two and then racked off. The tannin by this time will have separated the azotised matter from the liquor, and removed the ropiness. The wine is to be fined and bottled off.

The taste of the cask, which sometimes happens to wine put into casks which had remained long empty, is best remedied by agitating the wine for some time with a spoonful of olive oil. An essential oil, the chief cause of the bad taste, combines with the fixed oil, and rises with it to the surface.

According to a statement in the *Dictionnaire Technologique*, the annual produce of a hectare of vineyard, upon the average of 113 years, in the district of Volney, is 1779 litres, which fetch 0·877 francs each, or 200 francs the piece of 228 litres, amounting in all to 1672 francs. Deducting for expenses and taxes (*contributions*) 572 francs, there remain 1100 francs of net proceeds; and as the value of the capital may be estimated at 23,000 francs, the profit turns out to be no more than 5 per cent. The net proceeds in the growths of Beaune, Nuits, &c., does not exceed 600 francs per hectare (2·4 acres), and therefore is equivalent to only 2½ per cent. upon the capital.

The quantity of alcohol contained in different wines has been made the subject of elaborate experiments by Brande and Fontenelle; but as it must evidently vary with

different seasons, the results can be received merely as approximate. The only apparatus required for this research is a small still and refrigerator, so well fitted up as to permit none of the spirituous vapours to be dissipated. The distilled liquor should be received in a glass tube, graduated into one hundred measures, of such capacity as to contain the whole of the alcohol which the given measure of wine employed is capable of yielding. In the successive experiments, the quantity of wine used, and of spirit distilled over, being the same in volume, the relative densities of the latter will show at once the relative strengths of the wines. A very neat small apparatus has been contrived for the purpose of analysing wines in this manner, by M. Gay Lussac. It is constructed, and sold at a moderate price by M. Collardeau, No. 56, Rue Faubourg St. Martin, Paris. The proportion given by Brände (Table I.), has been reduced to the standard of absolute alcohol by Fesser; and that by Fontenelle (Table II.), to the same standard by Schubarth; as in the following tables:—

TABLE I.

| Name of the Wine. | Sp. Grav. | 100 Measures, contain at 60° Fahr. | | Name of the Wine. | Sp. Grav. | 100 Measures, contain at 60° Fahr. | |
|-------------------|-----------|---------------------------------------|----------------------|--------------------|-----------|---------------------------------------|----------------------|
| | | Alcohol of 0·833. | Absolute Alcohol. | | | Alcohol of 0·833. | Absolute Alcohol. |
| Port Wine | 0·97616 | 21·40 | 19·83 | Frontignac | 0·96452 | 17·79 | 11·84 |
| Do. | 0·97300 | 25·83 | 23·93 | Cote-Rot | 0·96495 | 12·37 | 11·36 |
| Do. | 0·97460 | 23·49 | 21·75 | Roussillon | 0·98005 | 17·24 | 15·96 |
| Madeira | 0·97810 | 19·24 | 17·91 | Cape Madeira | 0·97924 | 18·11 | 16·77 |
| Do. | 0·97383 | 21·43 | 22·61 | Muscate | 0·97913 | 18·26 | 17·00 |
| Sherry | 0·97913 | 18·25 | 17·00 | Constantia | 0·97770 | 19·75 | 18·29 |
| Do. | 0·97700 | 19·53 | 18·37 | Tinto | 0·96399 | 13·30 | 12·32 |
| Bordeaux, Claret | 0·97410 | 12·91 | 11·96 | Sehiras | 0·98176 | 18·53 | 14·35 |
| Do. | 0·97092 | 16·23 | 15·11 | Syracuse | 0·98200 | 15·23 | 14·15 |
| Calcavella | 0·97920 | 18·10 | 16·76 | Nice | 0·98263 | 14·63 | 13·64 |
| Lisbon | 0·97846 | 18·94 | 17·45 | Tokay | 0·98760 | 9·88 | 9·15 |
| Malaga | 0·98000 | 17·25 | 15·96 | Raisin wine | 0·97303 | 25·77 | 23·85 |
| Bucellas | 0·97890 | 18·49 | 17·23 | Drained grape wine | 0·97925 | 18·11 | 16·77 |
| Red Madeira | 0·97899 | 18·40 | 17·04 | Lachrymas Christi | — | 19·70 | 18·24 |
| Malmsey | 0·98000 | 16·40 | 15·91 | Currant wine | 0·97896 | 20·55 | 19·08 |
| Marsala | 0·96190 | 15·26 | 14·31 | Gooseberry wine | 0·96850 | 11·84 | 10·96 |
| Do. | 0·98000 | 17·26 | 15·93 | Elder wine | — | — | — |
| Champagne (rose) | 0·98608 | 11·30 | 10·46 | Cyder | 0·96760 | 9·87 | 9·14 |
| Do. (white) | 0·96450 | 12·80 | 11·84 | Perry | — | — | — |
| Burgundy | 0·96300 | 14·53 | 13·24 | Brown stout | 0·99116 | 6·80 | 6·30 |
| Do. | 0·96540 | 11·95 | 11·06 | Ale | 0·96873 | 8·88 | 8·00 |
| White Hermitage | 0·97990 | 17·43 | 16·14 | Porter | — | 4·20 | 3·89 |
| Red do. | 0·96495 | 12·83 | 11·40 | Rum | 0·99494 | 23·68 | 49·71 |
| Hock | 0·96290 | 14·37 | 13·31 | Hollands | 0·98355 | 51·60 | 47·77 |
| Do. | 0·96873 | 8·83 | 8·00 | Scotch whiskey | — | 54·32 | 50·20 |
| Vin de Grave | 0·96450 | 12·80 | 11·84 | Irish whiskey | — | 53·50 | 49·91 |

TABLE II.

| Name of the Wine. | Absolute Alcohol. | Name of the Wine. | Absolute Alcohol. | Name of the Wine. | Absolute Alcohol. |
|-----------------------------------|----------------------|-------------------------------|----------------------|------------------------|----------------------|
| Roussillon (Eastern Pyrenees.) | — | Sijean 8 yrs. old | 8·635 | Montpellier 5 yrs. old | 7·413 |
| Rive-saltes 18 yrs. old | 9·156 | Narbonne 8 | 8·379 | Lumel 8 | 7·864 |
| Banyuls 18 | 9·223 | Lenignan 10 | 8·173 | Frontignan 5 | 7·096 |
| Collyouvre 15 | 9·080 | Mirepeisset 10 | 8·589 | Red Hermitage 4 | 5·838 |
| Salces 10 | 8·660 | Carcassonne 8 | 7·190 | White do. | 7·066 |
| Department of the Aude. | — | Department of FHe- ruault. | — | Burgundy 4 | 6·195 |
| Fitou and Leucaté | — | Nissau 9 | 7·896 | Grave 3 | 5·838 |
| 10 | 8·568 | Bosters 8 | 7·728 | Champagne(sparkling) | 8·880 |
| Lapalme 10 | 8·790 | Montagnac 10 | 8·108 | Do. white do. | 8·145 |
| — | — | Mèss 10 | 7·619 | Do. rose | 4·956 |
| — | — | — | — | Bordeaux | 6·186 |
| — | — | — | — | Toulouse | 8·027 |

WINES. In a case tried before the Court of Exchequer, at the instance of the Board of Customs, in December, 1843, of an attempt to obtain the drawback upon a large quantity of damaged claret offered for exportation, I had observed, in my examination of the wine, that on the addition to it of water of ammonia to supersaturate its acidity, a large flocculent precipitate of decomposed gluten fell, and the supernatant liquor lost its ruby colour, and became yellow-brown. I have tried sound samples of genuine claret, very old, as well as new, by the same test, and I have found the ruby colour to remain but little impaired; contrary to the allegation of the chemist of the

defendants in the lawsuit. The wine was declared by the verdict of a jury and the decision of the judge to be unworthy of being admitted for drawback, and therefore forfeited to the Crown.

WINES, BRITISH, are made either from infusions of dried grapes (raisins) or from the juices of native fruits, properly fermented. These wines are called sweets in the language of the Excise, under whose superintendence they were placed till 1834, when the duties upon them were repealed, as onerous to the trade and unproductive to the revenue. The raisins called Lexias are said to produce a dry flavoured wine; the Denias a sweet wine; the Black Smyrnas a strong-bodied wine, and the red Smyrnas and Valenciass a rich and full wine. The early spring months are the fittest time for the wine manufacture. The masses of raisins, on being taken out of the packages, are either beaten with mallets or crushed between rollers in order to loosen them, and are then steeped in water in large vats, between a perforated board at bottom and another at top. The water being after some time drawn off the swollen and softened fruit, pressure is applied to the upper board to extract all the soluble sweet matter, which passes down through the false bottom, and flows off by an appropriate pipe into fermenting tuns. The residuary fruit is infused with additional water, and then squeezed; a process which is repeated till all the sweets are drained off, after which the "rape" is subjected to severe pressure in a screw or hydraulic press. The wine, in the process of the vinous fermentation, is occasionally passed through a great body of the rape to improve its flavour, and also to modify the fermentative action; it is afterwards set to ripen in casks, clarified by being repeatedly racked off, and fined with isinglass.

WINES, DEACIDIFICATION OF. Under a somewhat similar title, Professor Liebig* published in his *Annalen* for last March, "a mean" (*ein mittel*) for effecting that valuable object on old stored (*alte abgelagerte*) Rhine wines. "Most of these wines," he says, "even of the most propitious growths, and in the best condition, contain a certain quantity of free tartaric acid, on whose presence many of their essential properties depend. The juice of all sorts of grapes contains bitartrate of potash, and that of those of the young shoots, in good years, is saturated with it. When the must of these sorts of grapes becomes fermented, the tartar diminishes in solubility proportionally as the alcohol increases, and a part of it falls along with the yeast. This deposit of tartar increases during the first years of the vating; the sides of the casks becoming encrusted more and more with its crystals, in consequence of the continual addition of the new wine to replace what of the liquid is lost by evaporation, so as to keep the casks full, and prevent the destruction of the whole. But this deposition has a limit. By the filling up, the wine receives a certain quantity of free tartaric acid, and thereby acquires, at a certain point of concentration, the faculty of re-dissolving the deposited tartar. In the storing of many of the finer wines, the tartar again disappears at a certain period. By progressive filling up, the proportion of acid proportionally augments, the taste and flavour of the wine are exalted, but the acid contents make the wine less agreeable in use. Amateurs and manufacturers should therefore welcome a mean of taking away the free tartaric acid without altering in any respect the quality of the wine. This mean is pure neutral tartrate of potash. When this salt, in concentrated solution, is added to such a fluid as the above, there results the sparingly soluble tartar (one part of which requires from 180 to 200 parts of water of ordinary temperature for its solution), the free acid combines with the neutral salt, and separates as bitartrate from the liquid. If we add to 100 parts of a wine which contains one part of free tartaric acid, one and a half parts of neutral tartrate of potash, there will separate by rest at 18°—19° C, two parts of crystalline tartar, and the wine contains now one half part of tartar dissolved, in which there are only 0·2 parts of the original free acid. In this case, 0·8 of the free acid have been withdrawn from the wine."

Such is the Professor's statement of the disease and its remedy, and were the fact proved that the sourness of old vatted wines, either of the Rhine or other vintages, proceeded from excess of tartaric acid, his mean would be equally useful as it is ingenious. In the London Docks, among the many thousand pipes and hogsheads of wine there stored up, numbers remain, from various circumstances, till they become so sour as to be hardly potable. Samples of such damaged wines have been brought to me for analysis and amelioration. My first object was to ascertain the amount and nature of the acidity. That point was approximately estimated by the proportion of a test alkaline solution that was saturated by a given quantity of the wine. Another portion of it being distilled nearly to dryness with the heat of a liquid bath, at the temperature of about 235° Fahr., the whole acetic acid was obtained, along with the alcohol and a trace of ammonia (in the form of acetate) present in many wines, from decomposition of the gluten. The residuum in the retort was generally found to consist of bitartrate of potash, mixed with colouring and extractive matter. It was digested in

* See *Pharm. Journ.*, page 90.

water, filtered, and tested by Liebig's plan, with a concentrated solution of neutral tartrate of potash, but no precipitate of bitartrate ensued, proving that no free tartaric acid was present. In fact, during the slow fermentation of old vatted wines, much of the alcohol and of the saccharine matter, with the whole of the easily decomposed free tartaric acid, seems to be acetified, which accounts for the large proportion of vinegar obtained in the distillation of such wines. When a little of that distilled liquor is restored to the filtered solution of the residuum, the mixture acquires the property of decomposing neutral tartrate of potash, just as pure vinegar, or malic acid does, by seizing a portion of the potash, and favouring the formation and precipitation of the bitartrate. In fact, the feeblest free acid is adequate to produce this result, on the great principle which forms the ground-work of Berthollet's *Chemical Statics*, a work too little studied by the modern race of chemists. If to the acidulous wines in the London Docks (the veritable *alte abgelagerte* of Liebig) solution of tartrate of potash be added as long as any precipitate of tartar takes place, much of the neutral salt is required, and of course much acetate of potash is formed, which being very soluble remains in the wine, and vitiates its taste. From these facts, which any one may easily verify, it appears to me that the Professor's *Mittel zur entsäuerung alter abgelagerter Rheinweine* is of no practical use. If the recent must contains a hurtful excess of free tartaric acid, it may no doubt be got rid of by his method.

I found that one part of bitartrate of potash is soluble in 151 parts of water at 65° Fahr. (about 18° C.) instead of in 180 to 200 as he stated. The specific gravity of the solution is 1·0034. — *Pharmaceutical Journal*, vol. viii. No. 2.

WINES, RHINE.

| Place of Growth. | Sort of Grapes. | Specific Gravity. | 100 parts yielded. | |
|------------------------|-----------------|-------------------------|--------------------|-------------------------|
| | | | Absolute Alcohol. | Dry Residue. |
| Steinberg - - | Riesling | 1·0025 | 10·87 | 9·94 |
| Rüdesheim - - | Orleans | 1·0025 | 12·65 | 5·39 |
| Marksbrunn - - | Riesling | 0·9985 | 11·60 | 5·10 |
| Gersenheim - - | - - | 0·9935 | 12·60 | 3·05 |
| Dirnheim - - | - - | 0·9925 | 9·84 | 2·18 |
| Weinheim Hulberg - | - - | 0·9925 | 11·70 | 2·18 |
| Worms, Liebfrauenmilch | - - | 0·9930 | 10·62 | 2·27 |
| Bingen, Scharlachberg | - - | { not deter- mined } | 12·10 | { not deter- mined } |
| Eisler, Kleimberger | - - | - - | 11·90 | - - |
| Wiesbaden - - | - - | - - | - - | - - |
| Neroberg - - | - - | 0·9950 | 10·83 | 2·78 |
| Wiesloch - - | - - | 0·9945 | 9·83 | 2·48 |

From the known prices of these wines, it is obvious that the proportion of alcohol, although one factor in determining the value of a wine, is not the only absolute one, nor does it stand in any fixed relation to the commercial value of the wine. It is remarkable that the finest sorts of wine contain a much greater proportion of solid substances in solution than the inferior sorts; and that the weight of the residue, which the Rhenish wines yield on evaporation, offers a safer criterion for determining their commercial value, than the proportion of alcohol. These solids disguise the acid, take off the acrid taste, and at the same time impart body, mellowness, and oiliness. Among the extractive matters of new wines are sugar, which gradually disappears by keeping; and also some imperfectly known gummy substances, which become brownish when the wine is submitted to evaporation. The presence of these in wine appears chiefly to be determined by the soil, and the condition and locality of the vineyard; and it is obvious that the qualities dependent upon these extractive matters cannot be replaced by sugar.

It is of importance that the free acid be not removed before the fermentation, because on its presence during this process, as well as during the storing, depend the taste and principal qualities.

WINE, FAMILY, may be made by the following recipe:—Take black, red, white currants, ripe cherries (black hearts are the best), and raspberries, of each an equal quantity. To 4 pounds of the mixed fruit, well bruised, put 1 gallon of clear soft water; steep three days and nights, in open vessels, frequently stirring up the magma; then strain through a hair sieve; press the residuary pulp to dryness, and add its juice

muscovado sugar ; let the solution stand other three days and nights, frequently skimming and stirring it up ; then tun it into casks, which should remain full, and purging at the bung-hole, about two weeks. Lastly, to every 9 gallons, put 1 quart of good Cognac brandy (but not the drugged imitations made in London with grain whiskey), and bung down. If it does not soon become fine, a steeping of isinglass may be stirred into the liquid, in the proportion of about half an ounce to 9 gallons. I have found that the addition of 1 oz. of cream of tartar to each gallon of the fermentable liquor, improves the quality of the wine, and makes it resemble more nearly the produce of the grape.

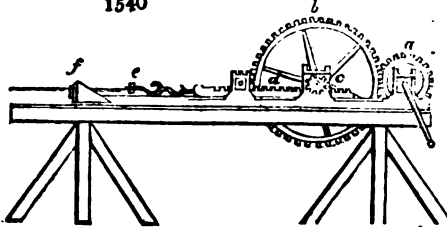
| Description. | Imported. | | Retained for Consumption. | | Duty received. | |
|--|-----------|-----------|---------------------------|-----------|----------------|-----------|
| | 1850. | 1851. | 1850. | 1851. | 1850. | 1851. |
| Cape - - - galls. | 224,779 | 407,153 | 216,496 | 224,794 | £ 25,606 | £ 32,914 |
| French - - - galls. | 600,243 | 764,931 | 265,483 | 468,486 | 106,277 | 124,812 |
| Canary, Fayal, Madeira, Portugal, Rhenish, and Spanish - - | 8,469,290 | 7,826,236 | 6,072,687 | 5,851,149 | 1,752,033 | 1,687,608 |
| Total | 9,304,312 | 9,008,420 | 6,684,666 | 6,554,429 | 1,892,916 | 1,866,331 |

WINE-STONE, is the deposit of crude tartar, called argal, which settles on the sides and bottoms of wine casks.

WIRE-DRAWING. (*Tréfilerie*, Fr. ; *Draht-ziehen*, *Drahtzug*, Germ.) When an oblong lump of metal is forced through a series of progressively diminishing apertures in a steel plate, so as to assume in its cross section the form and dimensions of the last hole, and to be augmented in length at the expense of its thickness, it is said to be wire-drawn. The piece of steel called the *draw-plate* is pierced with a regular gradation of holes, from the largest to the smallest ; and the machine for overcoming the lateral adhesion of the metallic particles to one another, is called the *draw-bench*. The pincers which lay hold of the extremity of the wire, to pull it through the successive holes, are adapted to bite it firmly, by having the inside of the jaws cut like a file. For drawing thick rods of gilt silver down into stout wire, the hydraulic press has been had recourse to with advantage.

Fig. 1540. represents a convenient form of the draw-bench, where the power is applied by a toothed wheel, pinion, and rack-work, moved by the hands of one or two men working

1540



the purpose of clearing off, or loosening at least, any crust of oxide formed in the annealing, before the wire enters the draw-plate.

When, for very accurate purposes of science or the arts, a considerable length of uniform wire is to be drawn, a plate with one or more jewelled holes, that is, filled with one or more perforated rubies, sapphires, or chrysolites, can alone be trusted to, because the holes even in the best steel become rapidly wider by abrasion. Through a hole in a ruby 0.0033 of an inch in diameter, a silver wire 170 miles long has been drawn, which possessed at the end the very same section as at the beginning ; a result determined by weighing portions of equal length, as also by measuring it with a micrometer. The hole in an ordinary draw-plate of soft steel becomes so wide, by drawing 14,000 fathoms of brass wire, that it requires to be narrowed before the original sized wire can be again obtained.

Wire, by being diminished one-half, one-third, one-fourth, &c., in diameter, is augmented in length respectively, four, nine, sixteen times, &c. The speed with which it may be prudently drawn out, depends upon the ductility and tenacity of the metal ; but may be always increased the more the wire becomes attenuated, because its particles

ing at a winch ; the motion being so regulated by a fly-wheel, that it does not proceed in fits and starts, and cause inequalities in the wire. The metal requires to be annealed, now and then, between successive drawings, otherwise it would become too hard and brittle for further extension. The reel upon which it is wound is sometimes mounted in a cistern of sour small beer, for

progressively assume more and more of the filamentous form, and accommodate themselves more readily to the extending force. Iron and brass wires, of 0·3 inch in diameter, bear drawing at the rate of from 12 to 15 inches per second; but when of 0·025 ($\frac{1}{40}$) of an inch, at the rate of from 40 to 45 inches in the same time. Finer silver and copper wire may be extended from 60 to 70 inches per second.

By enclosing a wire of platinum within one of silver ten times thicker, and drawing down the compound wire till it be $\frac{1}{30}$ of an inch, a wire of platinum of $\frac{1}{300}$ of an inch will exist in its centre, which may be obtained apart, by dissolving the silver away in nitric acid. This pretty experiment was first made by Dr. Wollaston.

The French draw-plates are so much esteemed, that one of the best of them used to be sold in this country, during the late war, for its weight in silver. The holes are formed with a steel punch; being made large on that side where the wire enters, and diminishing with a regular taper to the other side. In the act of drawing, they must be well supplied with grease for the larger kinds of wire, and with wax for the smaller.

WOAD (*Vouëde*, *Pastel*, Fr.; *Waid*, Germ.; *Isatis tinctoria*, Linn.); the *glastum* of the ancient Gauls and Germans; is an herbaceous plant which was formerly much cultivated, as affording a permanent blue dye, but it has been in modern times well nigh superseded by indigo. Pliny says, "A certain plant which resembles *plantago*, called *glastum*, is employed by the women and girls in Great Britain for dyeing their bodies all over, when they assist at certain religious ceremonies; they have then the colour of Ethiopians." — *Hist. Nat.* cap. xxii. § 2.

When the arts, which had perished with the Roman Empire, were revived, in the middle ages, woad began to be generally used for dyeing blue, and became an object of most extensive cultivation in many countries of Europe. The environs of Toulouse and Mirepoix, in Upper Languedoc, produce annually 40,000,000 pounds of the prepared woad, or pastel, of which 200,000 bales were consumed at Bordeaux. Beruni, a rich manufacturer of this drug, became surety for the payment of the ransom of his king, Francis I., then the prisoner of Charles V. in Spain.

The leaves of woad are fermented in heaps, to destroy certain vegetable principles injurious to the beauty of the dye, as also to elaborate the indigiferous matters present before they are brought into the market; but they should be carefully watched during this process. Whenever the leaves have arrived at maturity, a point judged of very differently in different countries, they are stripped off the plant, a cropping which is repeated as often as they shoot, being three or four times in Germany, and eight or ten times in Italy. The leaves are dried as quickly as possible, but not so much as to become black; and they are ground before they get quite dry. The resulting paste is laid upon a sloping pavement, with gutters for conducting the juice which exudes into a tank; the heap being tramped from time to time, to promote the discharge of the juice. The woad ferments, swells, and cracks in many places, which fissures must be closed; the whole being occasionally watered. The fermentation is continued for twenty or thirty days, in cold weather; and if the leaves have been gathered dry, as in Italy, for four months. When the fermented heap has become moderately dry, it is ground again, and put up in cakes of from one to three pounds; which are then fully dried, and packed up in bundles for the market. Many dyers subject the pastel to a second fermentation.

1,600 square toises (fathoms) of land afford in two cuttings at least 19,000 pounds of leaves, of which weight four-fifths are lost in the fermentation, leaving 3,880 pounds of pastel, in leaves or cakes. When good, it has rather a yellow, or greenish-yellow, than a blue colour; it is light, and slightly humid; it gives to paper a pale-green trace; and improves by age, in consequence of an obscure fermentation; for if kept four years, it dyes twice as much as after two years. According to Hellot, 4 pounds of Guatemala indigo produce the same effect as 210 pounds of the pastel of Albi. At Quins in Piedmont, the dyers estimate that 6 pounds of indigo are equivalent to 300 of pastel; but Chaptal thinks the indigo underrated.

Pastel will dye blue of itself, but it is commonly employed as a fermentative addition to the proper blue vat, as described under INDIGO.

Fresh woad, analyzed by Chevreul, afforded, in 100 parts, 65·4 of juice. After being steeped in water, the remaining mass yielded, on expression, 29·65 of liquid; being in whole, 95·05 parts, leaving 4·95 of ligneous fibre. The juice, by filtration, gave 1·95 of green fecula. 100 parts of fresh woad, when dried, are reduced to 13·76 parts. Alcohol, boiled upon dry woad, deposits, after cooling, indigo in microscopic needles; but these cannot be separated from the vegetable albumine, which retains a greenish-gray colour.

WOLFRAM, is the native tungstate of iron and manganese, a mineral which occurs in primitive formations, along with the ores of tin, antimony, and lead, in the Bohemian Erzgebirge, in Cornwall, Switzerland, North America, &c. It is used by chemists for obtaining tungstic acid and tungstenum.

WOOD (*Bois*, Fr.; *Holz*, Germ.); is the hard part between the pith and the bark of trees and shrubs, through which the chief part of the juices are conducted from the root towards the branches and leaves, during the life of the vegetable. The ligneous fibre is the substance which remains after the plant has been subjected to the solvent action of ether, alcohol, water, dilute acids, and caustic alkaline lyes. It is considered by chemists that dry timber consists, on an average, of 96 parts of fibrous and 4 of soluble matter, in 100; but that these proportions vary somewhat with the seasons, the soil, and the plant. All kinds of wood sink in water, when placed in a basin of it under the exhausted receiver of an air-pump; showing their specific gravity to be greater than 1.000. That of fir and maple is stated, by chemical authors, to be 1.46; and that of oak and beech, at 1.53; but I believe them to have all the same spec. grav. as the fibre of flax; namely, 1.50, as determined by me some years ago.*

Wood becomes snow-white, when exposed to the action of chlorine; digested with sulphuric acid, it is transformed first into gum, and, by ebullition with water afterwards into grape-sugar; with concentrated nitric acid, it grows yellow, loses its coherence, falls into a pulverulent mass, but eventually dissolves, and is converted into oxalic acid; with strong caustic alkaline lyes, in a hot state, it swells up excessively, dissolves into a homogeneous liquid, and changes into a blackish-brown mass, containing oxalic and acetic acids.

The composition of wood has been examined by Gay Lussac and Thenard, and Dr. Prout. The first two chemists found it to consist, in 100 parts, of—

| | | | |
|----------|---|-------|--------|
| | | Oak. | Beech. |
| Carbon | - | 52.53 | 51.45 |
| Hydrogen | - | 5.69 | 5.82 |
| Oxygen | - | 41.78 | 42.73 |

According to Dr. Prout, the oxygen and hydrogen are in the exact proportions to form water. Willow contains 50, and box 49.8 per cent. of carbon; each containing, therefore, very nearly 44.444 of oxygen, and 5.555 of hydrogen. In the analyses of Gay Lussac and Thenard, there is a great excess of hydrogen above what the oxygen requires

TABLE of the DISTILLATION of ONE POUND of WOOD, dried, at 86° Fahr.

| Name of the Wood. | Weight of Wood Acid. | One Ounce of the Acid Saturates of Carbonate of Potash. | Weight of the combustible Oil. | Weight of the Charcoal. |
|------------------------------------|----------------------|---|--------------------------------|-------------------------|
| | Ounces. | Grains. | Ounces. | Ounces. |
| White birch - - - | 7 | 44 | 1½ | 3½ |
| Red beech - - - | 7 | 44 | 1½ | 3½ |
| Prick wood (spindle tree) - - - | 7½ | 40 | 1½ | 3½ |
| Large leaved linden - - - | 6¾ | 41 | 2 | 3½ |
| Red or scarlet oak - - - | 7 | 40 | 1½ | 4 |
| White beech - - - | 6½ | 40 | 1½ | 3½ |
| Common ash - - - | 7½ | 34 | 1½ | 3½ |
| Horse chestnut - - - | 7½ | 31 | 1½ | 3½ |
| Italian poplar - - - | 7½ | 30 | 1½ | 3½ |
| Silver poplar - - - | 7½ | 30 | 1½ | 3½ |
| White willow - - - | 7½ | 28 | 1½ | 3½ |
| Root of the sassafras laurel - - - | 6¾ | 29 | 1½ | 4 |
| Wild service tree - - - | 7 | 28 | 1½ | 3½ |
| Basket willow - - - | 8 | 27 | 1½ | 3½ |
| Dogberry tree - - - | 7 | 27 | 2 | 3½ |
| Buckthorn - - - | 7½ | 26 | 1½ | 3½ |
| Logwood - - - | 7½ | 26 | 1½ | 4 |
| Alder - - - | 7½ | 22 | 1½ | 3½ |
| Juniper - - - | 7½ | 23 | 1½ | 3½ |
| White fir (deal) - - - | 6½ | 23 | 2½ | 3½ |
| Common pine wood - - - | 6¾ | 22 | 1½ | 3½ |
| Savine tree - - - | 7 | 20 | 1½ | 3½ |
| Red deal (pine) - - - | 6½ | 18 | 2½ | 3½ |
| Guaiac wood - - - | 6 | 16 | 2½ | 4 |

* From the small difference found by experiment between the specific gravity of flax (1.50) and of cotton (1.47), I am inclined to think that the density of both may be considered to be equal, or 1.50.—*Philosophy of Manufactures*, 2d edition, pp. 97, 98, 99.

to form water. Authenrieth stated, some years ago, that he found that fine sawdust, mixed with a sufficient quantity of wheat flour, made a coherent dough with water, which formed an excellent food for pigs; apparently showing that the digestive organs of the animal could operate the same sort of change upon wood as sulphuric acid does.

WOOD-PRESERVING. Mr. Bethell's invention consists in impregnating wood throughout with oil of tar and other bituminous matters, containing creosote, and also with pyrolignite of iron, which holds more creosote in solution than any other watery menstruum.

The wood is put in a close iron tank, like a high-pressure steam-boiler, which is then closed and filled with the tar oil or pyrolignite. The air is then exhausted by air-pumps, and afterwards more oil or pyrolignite is forced in by hydrostatic pumps, until a pressure equal to from 100 to 150 pounds to the inch is obtained. This pressure is kept up by the frequent working of the pumps during six or seven hours, whereby the wood becomes thoroughly saturated with the tar oil, or the pyrolignite of iron, and will be found to weigh from 8 to 12 pounds per cube foot heavier than before.

In a large tank, like one of those used on the Bristol and Exeter Railway, 20 loads of timber per day can be prepared.

The effect produced is that of perfectly coagulating the albumen in the sap, thus preventing its putrefaction. For wood that will be much exposed to the weather, and alternately wet and dry, the mere coagulation of the sap is not sufficient; for although the albumen contained in the sap of the wood is the most liable and the first to putrefy, yet the ligneous fibre itself, after it has been deprived of all sap, will, when exposed in a warm damp situation, rot and crumble into dust. To preserve wood, therefore, that will be much exposed to the weather, it is not only necessary that the sap should be coagulated, but that the fibres should be protected from moisture, which is effectually done by this process.

The atmospheric action on wood thus prepared renders it tougher, and infinitely stronger. A post made of beech, or even of Scotch fir, is rendered more durable, and as strong as one made of the best oak; the bituminous mixture with which all its pores are filled acting as a cement to bind the fibres together in a close tough mass; and the more porous the wood is, the more durable and tough it becomes, as it imbibes a greater quantity of the bituminous oil, which is proved by its increased weight. The materials which are injected preserve iron and metals from corrosion; and an iron bolt driven into wood so saturated remains perfectly sound and free from rust. It also resists the attack of insects; and it has been proved by Mr. Prichard, at Shoreham Harbour, that the *teredo navalis*, or naval worm, will not touch it.

Wood thus prepared for sleepers, piles, posts, fencing, &c., is not at all affected by alternate exposure to wet and dry; it requires no painting, and after it has been exposed to the air for some days it loses every unpleasant smell.

This process has been adopted by the following eminent engineers — viz., Mr. Robert Stephenson, Mr. Brunel, Mr. Bidder, Mr. Braithwaite, Mr. Buck, Mr. Harris, Mr. Wickstead, Mr. Prichard, and others; and has been used with the greatest success on the Great Western Railway, the Bristol and Exeter Railway, the Manchester and Birmingham Railway, the North Eastern, the South Eastern, the Stockton and Darlington, and at Shoreham Harbour; and lately, in consequence of the excellent appearance of the prepared sleepers, after three years' exposure to the weather, an order has been issued by Mr. Robert Stephenson, that the sleepers hereafter to be used on the London and Birmingham Railway are to be prepared with it before being put down.

The expense of preparing the wood varies from 10s. to 15s. per load, according to situation, and the distance from the manufactories where the material is made.

Mr. Bethell supplies the material at a low price from his manufactories, either at Nine Elms, Vauxhall; Bow Common; or Birmingham; and also parties prepare the timber themselves.

For railway sleepers it is highly useful, as the commonest Scotch fir sleeper, when thus prepared, will last for centuries. Those which have been in use 3 years and upwards look much better now than when first laid down, having become harder, more consolidated, and perfectly waterproof; which qualities, combined with that of perfectly resisting the worm, render this process eminently useful for piles, and all other woodwork placed under water. Posts for gates or fencing, if prepared in this manner, may be made of Scotch fir, or the cheapest wood that can be obtained, and will not decay like oak posts, which invariably become rotten near the earth after a few years.

WOOF, is the same as WERR.

WOOLLEN MANUFACTURE. In reference to textile fabrics, sheep's wool is of two different sorts, the short and the long-stapled; each of which requires different modes of manufacture in the preparation and spinning processes, as also in the treatment of the cloth after it is woven, to fit it for the market. Each of these is, moreover, distinguished in commerce by the names of fleece wools and dead wools, according as they

have been shorn at the usual annual period from the living animal, or are cut from its skin after death. The latter are comparatively harsh, weak, and incapable of imbibing the dyeing principles, more especially if the sheep has died of some malignant distemper. The annular pores, leading into the tubular cavities of the filaments, seem, in this case, to have shrunk and become obstructed. The time of year for cheap-shearing most favourable to the quality of the wool, and the comfort of the animal, is towards the end of June and beginning of July; — the period when Lord Leicester holds his celebrated rural fête for that interesting purpose.

The wool of the sheep has been surprisingly improved by its domestic culture. The *mouflon* (*Ovis aries*), the parent stock from which our sheep is undoubtedly derived, and which is still found in a wild state upon the mountains of Sardinia, Corsica, Barbary, Greece, and Asia Minor, has a very short and coarse fleece, more like hair than wool. When this animal is brought under the fostering care of man, the rank fibres gradually disappear; while the soft wool round their roots, little conspicuous in the wild animal, becomes singularly developed. The male most speedily undergoes this change, and continues ever afterwards to possess far more power in modifying the fleece of the offspring, than the female parent. The produce of a breed from a coarse-woolled ewe and a fine-woolled ram, is not of a mean quality between the two, but half-way nearer that of the sire. By coupling the female thus generated with such a male as the former, another improvement of one-half will be obtained, affording a staple three-fourths finer than that of the grandam. By proceeding inversely, the wool would be as rapidly deteriorated. It is, therefore, a matter of the first consequence in wool husbandry, to exclude from the flock all coarse-fleeced rams.

Long wool is the produce of a peculiar variety of sheep, and varies in the length of its fibres from 3 to 8 inches. Such wool is not carded like cotton, but combed like flax, either by hand or appropriate machinery. Short wool is seldom longer than 3 or 4 inches; it is susceptible of carding and felting, by which processes the filaments become first convoluted, and then densely matted together. The shorter sorts of combing wool are used principally for hosiery, though of late years the finer kinds have been extensively worked up into merino and mousseline-de-laine fabrics. The longer wools of the Leicestershire breed are manufactured into hard yarns, for worsted-pieces, such as waistcoats, carpets, bombazines, poplins, crapes, &c.

The wool of which good broad cloth is made should be not only shorter, but, generally speaking, finer and softer than the worsted wools, in order to fit them for the fulling process. Some wool-sorters and wool-staplers acquire by practice great nicety of discernment in judging of wools by the touch and traction of the fingers. Some years ago I made a series of observations upon different wools, and published the results. The filaments of the finer qualities varied in thickness from $\frac{1}{100}$ to $\frac{1}{125}$ of an inch; their structure is very curious, exhibiting, in a good achromatic microscope, at intervals of about $\frac{1}{30}$ of an inch, a series of serrated rings, imbricated towards each other, like the joints of *Equisetum*, or rather like the scaly zones of a serpent's skin. See *Philosophy of Manufactures*, figs. 11, 12., page 91. second edition.

There are four distinct qualities of wool upon every sheep; the finest being upon the spine, from the neck to within 6 inches of the tail, including one-third of the breadth of the back; the second covers the flanks between the thighs and the shoulders; the third clothes the neck and the rump; and the fourth extends upon the lower part of the neck and breast down to the feet, as also upon a part of the shoulders and the thighs, to the bottom of the hind quarter. These should be torn asunder, and sorted, immediately after the shearing.

The harshness of wools is dependent not solely upon the breed of the animal, or the climate, but is owing to certain peculiarities in the pasture, derived from the soil. It is known, that in sheep fed upon chalky districts, wool is apt to get coarse; but in those upon a rich loamy soil, it becomes soft and silky. The ardent sun of Spain renders the fleece of the Merino breed harsher than it is in the milder climate of Saxony. Smearing sheep with a mixture of tar and butter is deemed favourable to the softness of their wool.

All wool, in its natural state, contains a quantity of a peculiar potash-soap, secreted by the animal, called in this country the *yoak*; which may be washed out by water alone, with which it forms a sort of lather. It constitutes from 25 to 50 per cent. of the wool, being most abundant in the Merino breed of sheep; and however favourable to the growth of the wool on the living animal, should be taken out soon after it is shorn, lest it injure the fibres by fermentation, and cause them to become hard and brittle. After being washed in water, somewhat more than lukewarm, the wool should be well pressed, and carefully dried.

Mr. Hicks, of Huddersfield, obtained a patent some years ago for a machine for cleaning wool from burs. It consists of 4 rotary beaters, which act in succession. The wool having been opened and spread upon a feeding cloth is carried by it to the drawing rollers,

and is then delivered to the action of the beater, by which it is carried along a curved grating to the feed cloth of another beater, so as to be made eventually quite clean.

England grows annually about 1,000,000 packs of wool. The quantity imported into the United Kingdom, in 1850, was 72,674,483 lbs.; in 1851, 81,063,679 lbs.; of which 48,240,529 lbs. and 51,993,463 lbs. respectively were from British possessions.

Having premised these general observations on wool, I shall now proceed to treat of its manufacture, beginning with that of wool-combing, or

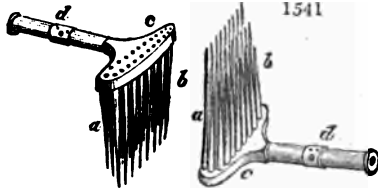
THE WORSTED MANUFACTURE.

In this branch of business, a long stapled and firm fibre is required to form a smooth level yarn, little liable to shrink, curl or felt in weaving and finishing the cloth. It must not be entangled by carding, but stretched in lines as parallel as possible by a suitable system of *combing*, manual or mechanical.

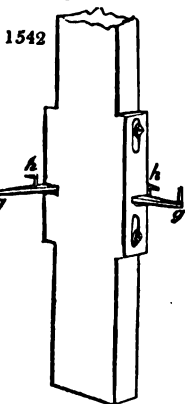
When the long wool is brought into the worsted factory, it is first of all washed by men with soap and water, who are paid for their labour by the piece, and are each assisted by a boy, who receives the wool as it issues from between the drying *squeezers* (see BLEACHING). The boy carries off the wool in baskets, and spreads it evenly upon the floor of the drying-room, usually an apartment over the boilers of the steam-engine, which is thus economically heated to the proper temperature. The health of the boys employed in this business is found to be not at all injured.

The wool, when properly dried, is transferred to a machine called the *plucker*, which is always superintended by a boy of 12 or 14 years of age, being very light work. He lays the tresses of wool pretty evenly upon the feed-apron, or table covered with an endless moving web of canvas, which, as it advances, delivers the ends of the long tufts to a pair of fluted rollers, whence it is introduced into a fanning apparatus, somewhat similar to the *willow* employed in the cotton manufacture, which see. The filaments are turned out at the opposite end of this winnowing machine, straightened, cleaned, and ready for the combing operation. According to the old practice of the trade, and still

for the finer descriptions of the long staple, according to the present practice, the wool is carded by hand. This is far more severe labour than any subservient to machinery, and is carried on in rooms rendered close and hot by the number of stoves requisite to heat the combs, and so enable them to render the fibres soft, flexible, and elastic. This is a task at which only robust men are engaged. They use three implements;



1. a pair of combs for each person; 2. a post, to which one of the combs can be fixed; 3. a comb-pot or small stove for heating the teeth of the comb. Each comb is composed



either of two or three rows of pointed tapering steel teeth, *b*, *fig. 1541.*, disposed in two or three parallel planes, each row being a little longer than the preceding. They are made fast at the roots to a wooden stock or head *c*, which is covered with horn and has a handle *d*, fixed into it at right angles to the lines of the teeth. The spaces between these two or three planes of teeth is about one-third of an inch at their bottoms, but somewhat more at their tips. The first combing, when the fibres are most entangled, is performed with the two-row toothed combs; the second or finishing combing, with the three-row toothed.

In the workshop a post is planted (*fig. 1542.*) upright, for resting the combs occasionally upon, during the operation. An iron stem *g*, projects from it horizontally, having its end turned up, so as to pass through a hole in the handle of the comb. Near its point of insertion into the post, there is another staple point *h*, which enters into the hollow end of the handle; which, between these two catches, is firmly secured to the post. The stove is a very simple affair, consisting merely of a flat iron plate, heated by fire or steam, and surmounted with a similar plate, at an interval sufficient to allow the teeth

to be inserted between them at one side, which is left open, while the space between their edges, on the other sides, is closed to confine the heat.

In combing the wool, the workman takes it up in tresses of about four ounces each, sprinkles it with oil, and rolls it about in his hands, to render all the filaments equally

unctuous. Some harsh dry wools require one-sixteenth their weight of oil, others no more than a fortieth. He next attaches a heated comb to the post, with its teeth pointed upwards, seizes one-half of the tress of wool in his hands, throws it over the teeth, then draws it through them, and thus repeatedly: leaving a few straight filaments each time upon the comb. When the comb has in this way collected all the wool, it is placed with its points inserted into the cell of the stove, with the wool hanging down outside, exposed to the influence of the heat. The other comb, just removed in a heated state from the stove, is planted upon the post, and furnished in its turn with the remaining two-ounce tress of wool; after which it supplants the preceding at the stove. Having both combs now hot, he holds one of them with his left hand over his knee, being seated upon a low stool, and seizing the other with his right hand, he combs the wool upon the first, by introducing the teeth of one comb into the wool stuck in the other, and drawing them through it. This manipulation is skillfully repeated, till the fibres are laid truly parallel like a flat tress of hair. It is proper to begin by combing the tips of the tress, and to advance progressively, from the one end towards the other, till at length the combs are worked with their teeth as closely together as is possible, without bringing them into collision. If the workman proceeded otherwise, he would be apt to rupture the filaments, or tear their ends entirely out of one of the combs. The flocks left at the end of the process, because they are too short for the comb to grasp them in his hand, are called *noyis*. They are unfit for the worsted spinner, and are reserved for the coarse cloth manufacture.

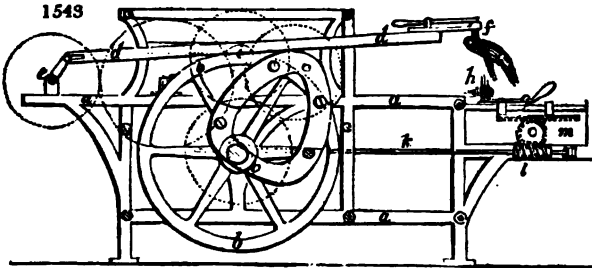
The wool finally drawn off from the comb, though it may form a uniform tress of straight filaments, must yet be combed again at a somewhat lower temperature, to prepare it perfectly for the spinning operation. From ten to twelve slivers are then arranged in one parcel.

To relieve the workman from this laborious and not very salubrious task has been the object of many mechanical inventions. One of these, considerably employed in this country and in France, is the invention of the late Mr. John Collier, of Paris, for which a patent was obtained in England, under the name of John Platt, of Salford, in November, 1827. It consists of two comb-wheels, about ten feet in diameter, having hollow iron spokes filled with steam, in order to keep the whole apparatus at a proper combing heat. The comb forms a circle, made fast to the periphery of the wheel, the teeth being at right angles to the plane of the wheel. The shafts of the two wheels are mounted in a strong frame of cast-iron; not, however, in horizontal positions, but inclined at acute angles to the horizon, and in planes crossing each other, so that the teeth of one circular comb sweep with a steady obliquity over the teeth of the other, in a most ingenious manner, with the effect of combing the tresses of wool hung upon them. The proper quantity of long wool, in its ordinary state, is stuck in handfuls upon the wheel, revolving slowly, by a boy, seated upon the ground at one side of the machine. Whenever the wheel is dressed, the machine is made to revolve more rapidly, by shifting its driving-band on another pulley; and it is beautiful to observe the delicacy and precision with which it smoothes the tangled tress. When the wools are set in rapid rotation, the loose ends of the fleece, by the centrifugal force, are thrown out, in the direction of radii, upon the teeth of the other revolving comb-wheel, so as to be drawn out and made truly straight. The operation commences upon the tips of the tresses, where the wheels, by the oblique posture of their shafts, are at the greatest distance apart; but as the planes slowly approach to parallelism, the teeth enter more deeply into the wool, till they progressively comb the whole length of its fibres. The machines being then thrown out of gear, the teeth are stripped of the tresses by the hand of the attendant; the *noyis*, or short refuse wool, being also removed, and kept by itself.

This operation being one of simple superintendence, not of handicraft effort and skill, like the old combing of long wool, is now performed by boys or girls of 13 and 14 years of age; and places in a striking point of view the influence of automatic mechanism, in so embodying dexterity and intelligence in a machine, as to render the cheap and tractable labour of children a substitute for the high-priced and often refractory exertions of workmen too prone to capricious combinations. The chief precaution to be taken with this machine, is to keep the steam-joints tight, so as not to wet the apartments and to provide due ventilation for the operatives.

The following machine, patented by James Noble, of Halifax, worsted-spinner, in February, 1834, deserves particular notice, as its mode of operation adapts it well also for heckling flax. In *fig. 1543*, the internal structure is exhibited. The frame-work *a, a*, supports the axle of a wheel *b, b*, in suitable bearings on each side. To the face of this wheel is affixed the eccentric or heart-wheel cam *c, c*. On the upper part of the periphery of this cam or heart-wheel, a lever *d, d*, bears merely by its gravity; one end of which lever is connected by a joint to the crank *e*. By the rotation of the crank *e*, it will be perceived that the lever *d*, will be slidden to and fro on the upper part of the periphery of the eccentric or heart-wheel cam *c*, the outer end of the lever *d*, carrying

the upper or working comb of needle-points *f*, as it moves, performing an elliptical curve, which curve will be dependent upon the position of the heart-wheel cam *c*, that guides it. A movable frame *g*, carries a series of points *h*, which are to constitute the lower comb or frame of needles. Into these lower needles the rough uncombed



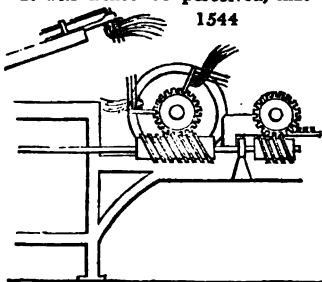
wool is to be fed by hand, and to be drawn out and combed straight by the movements of the upper or working comb.

As it is important, in order to prevent waste, that the ends of the wool should be first combed out, and that the needle-points should be made to penetrate the wool progressively, the movable frame *g*, is in the first instance placed as far back as possible; and the action of the lever *d*, during the whole operation, is so directed by the varying positions of the cam-wheel, as to allow the upper comb to enter at first a very little way only into the wool; but as the operation of combing goes on, the frame with the lower combs is made to advance gradually, and the relative positions of the revolving heart cam-wheel *c*, being also gradually changed, the upper or working needles are at length allowed to be drawn completely through the wool, for the purpose of combing out straight the whole length of its fibre.

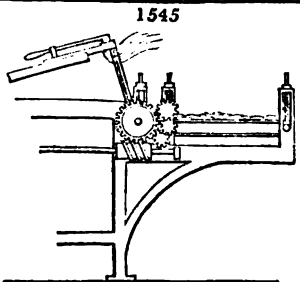
In order to give to the machine the necessary movements, a train of toothed wheels and pinions is mounted, mostly on studs attached to the side of the frame; which train of wheels and pinions is shown by dots in the figure, to avoid confusion. The driving power, a horse or steam-engine, is communicated by a band to a rigger on the short axle *i*; which axle carries a pinion, taking into one of the wheels of the train. From this wheel the crank *e*, that works the lever *d*, is driven; and also, by gear from the same pinion, the axle of the wheel *b*, carrying the eccentric or heart-wheel cam, is also actuated, but slower than the crank-axle.

At the end of the axle of the wheel *b*, and cam *c*, a bevel pinion is affixed, which gears into a corresponding bevel pinion on the end of the lateral shaft *k*. The reverse end of this shaft has a worm or endless screw *l*, taking into a toothed wheel *m*; and this last-mentioned toothed wheel gears into a rack at the under part of the frame *g*.

It will hence be perceived, that by the movements of the train of wheels, a slow motion is given to the frame *g*, by which the lower needles carrying the wool are progressively advanced as the operation goes on; and also, that by the other wheels of the train, the heart-wheel cam is made to rotate, for the purpose of giving such varying directions to the stroke of the lever which slides upon its periphery, and to the working comb, as shall cause the comb to operate gradually upon the wool as it is brought forward. The construction of the frames which hold the needles, and the manner of fixing them in the machine, present no features of importance; it is therefore unnecessary to describe them farther, than to say, that the heckles are to be heated when used for combing wool.



Instead of introducing the wool to be combed into the lower needles by hand, it is sometimes fed in, by means of an endless feeding-cloth, as shown in *fig. 1544*. This endless cloth is distended over two rollers, which are made to revolve, for the purpose of carrying the cloth with the wool forward, by means of the endless screw and pinions.



A slight variation in the machine is shown at *fig. 1545*, for the purpose of combing wool of long fibre, which differs from the former only in placing the combs or needle points upon a revolving cylinder or shaft. At the end of the axle of this shaft, there is a toothed wheel, which is actuated by an

endless screw upon a lateral shaft. The axle of the cylinder in which the needles are fixed, is mounted in a movable frame or carriage, in order that the points of the needles may, in the first instance, be brought to act upon the ends of the wool only, and ultimately be so advanced as to enable the whole length of the fibres to be drawn through. The progressive advancement of this carriage, with the needle cylinder, is effected by the agency of the endless screw on the lateral shaft before mentioned.

Some combing-machines reduce the wool into a continuous sliver, which is ready for the drawing-frame; but the short slivers produced by the hand combing, must be first joined together, by what is called *planking*. These slivers are rolled up by the combers ten or twelve together, in balls called *tops*, each of which weighs half a pound. At the spinning-mill these are unrolled, and the slivers are laid on a long plank or trough, with the ends lapping over, in order to splice the long end of one sliver into the short end of another. The long end is that which was drawn off first from the comb, and contains the longer fibres; the short is that which comes last from the comb, and contains the shorter. The wool-comber lays all the slivers of each ball the same way, and marks the long end of each by twisting up the end of the sliver. It is a curious circumstance, that when a top or ball of slivers is unrolled and stretched out straight, they will not separate from each other without tearing and breaking, if the separation is begun at the short ends; but if they are first parted at the long ends, they will readily separate.

The machine for combing long wool, for which Messrs. Donisthorpe and Rawson obtained a patent in April, 1835, has been found to work well, and therefore merits a detailed description:—

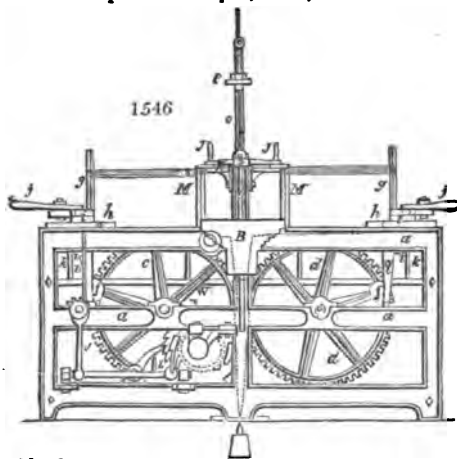
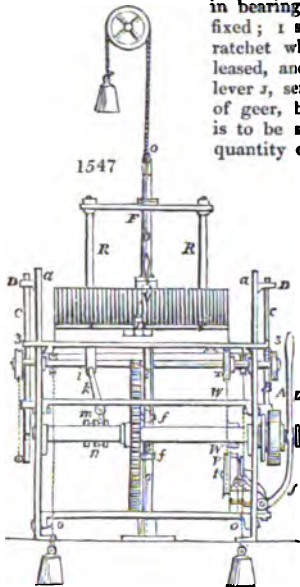


Fig. 1546. is an elevation; *fig.* 1547. an end view; and *fig.* 1548. a plan; in which *a, a*, is the framing; *b*, the main shaft, bearing a pinion which drives the wheel *d*, on the shaft *e*. Upon each of the wheels *e* and *d*, there are two projections or studs *f*, which cause the action of the combs *g, g*, of which *h, h*, are the tables or carriages. These are capable of sliding along the upper guide rails of the framing *a*. Through these carriages or tables *h, h*, there are openings or slits, shown by dotted lines, which act as guides to the holders *i, i*, of the combs *g, g*, rendering the holders susceptible of motion at right angles to the course pursued by the

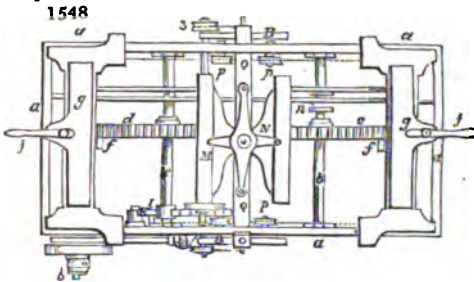
tables *h*. The combs are retained in the holders *i, i*, by means of the lever handles *j, j*, which move upon inclined surfaces, and are made to press on the surface of the heads of the combs *g, g*, so as to be retained in their places; and they are also held by studs affixed to the holders, which pass into the comb-heads. From the under side of the tables, forked projections *i, i*, stand out, which pass through the openings or slits formed in the tables *h, h*; these projections are worked from side to side by the frame *k, k*, which turning on the axis or shaft *l, l*, is caused to vibrate, or rock to and fro, by the arms *m*, moved by the eccentric groove *n*, made fast to the shaft *e*. The tables *h*, are drawn inwards, by weights suspended on cords or straps *o, o*, which pass over friction pulleys *p, p*; whereby the weights have a constant tendency to draw the combs into the centre of the machine, as soon as it is released by the studs *f*, passing beyond the projecting arms *g*, on the tables. On the shaft *c*, a driving-tooth or catch *r*, is fixed, which takes into the ratchet wheel *s*, and propels one of its teeth at every revolution of the shaft *c*. This ratchet wheel turns on an axis at *t*; to the ratchet the pulley *v* is made fast, to which the cord or band *w* is secured, as also to the pulley *x*, on the shaft *y*. On the shaft *y*, there are two other pulleys *z, z*, having the cords or bands *u, u*, made fast to them, and also to the end of the gauge-plates *z*, furnished with graduated steps, against which the tables *h, h*, are drawing at each operation of the machine. In proportion as these gauge-plates are raised, the nearer the carriages or tables *h*, will be able to advance to the centre of the machine, and thus permit the combs *g, g*, to lay hold of, and comb, additional lengths of the woolly fibres. The gauge-plates *z*, are guided up by the bars *c*, which pass through openings, slots, or guides, made in the framing *a*, as shown by *d*.

To the ratchet wheel *s*, an inclined projection *x*, is made fast, which in the course of the rotation of the ratchet wheel, comes under the lever *r*, fixed to the shaft *o*, that turns in bearings *u*. To this shaft the levers *i* and *j*, are also fixed; *i* serving to throw out the click or catch *κ*, from the ratchet wheel, by which the parts of the machine will be released, and restored to positions ready for starting again. The lever *j*, serves to slide the drum upon the driving shaft *b*, out of gear, by means of the forked handle *l*, when the machine is to be stopped, whenever it has finished combing a certain quantity of wool.



The combs which hold the wool have a motion upwards, in order to take the wool out of the way of the combs *g*, *g*, as these are drawn into the centre of the machine; while the holding combs descend to lay the wool among the points of the combs *g*, *g*. For obtaining this upward and downward motion, the combs *m*, *m*, are placed upon the frame *x*, and retained there just as the combs *g*, *g*, are upon the holders *i*, *i*. The framing *x* is made fast to the bar or spindle *o*, which moves vertically through openings in the cross-head *r*, and the cross-framing of the machine *q*; from the top of which, there is a strap passes over pulleys with a weight suspended to it; the cross-head being supported by the two guide-rods *n*, fixed to the cross-framing *q*. It is by the guide-rods *n*, and the spindle *o*, that the frame *x* is made to move up and down; while the spindle is made to rise by the studs *f*, as the wheels *c* and *d* come successively under the studs *s*, on the spindle *o*.

A quantity of wool is to be placed on each of the combs *g*, *g*, and *m*, *m*, the machine being in the position shown in *fig. 1548*. When the main shaft *b*, is set in motion, it will drive by its pinion the toothed wheel *e*, and therefrom the remaining parts of the machine.



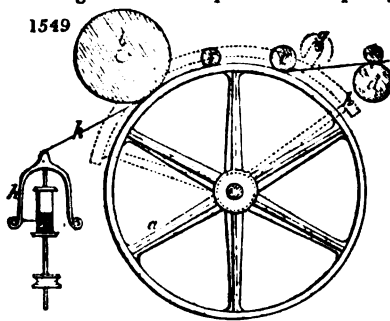
The first effect of the movement will be to raise the combs *m*, *m*, sufficiently high to remove the wool out of the way of the combs *g*, *g*, which will be drawn towards the centre of the machine, as soon as they are released by the studs *f*, passing the projecting arms *q*, on the tables *h*; but the distance between the combs *g*, *g*, and the combs *m*, *m*, will depend on the height to which the gauge-plates *a*, have been raised. These plates are

raised one step at each revolution of the shaft *c*; the combs *g*, *g*, will therefore be continually approaching more nearly to the combs *m*, *m*, till the plates *a*, are so much raised as to permit the tables *h*, to approach the plates *a*, below the lowest step or graduation, when the machine will continue to work. Notwithstanding the plates *a*, continuing to rise, there being only parallel surfaces against which the tables come, the combs *g*, *g*, will successively come to the same position, till the inclined projection *x*, on the ratchet wheel *s*, comes under the lever *r*, which will stop the machine. The wool which has been combed, is then to be removed, and a fresh quantity introduced. It should be remarked, that the combs *g*, *g*, are continually moving from side to side of the machine, at the same time that they are combing out the wool. The chief object of the invention is obviously to give the above peculiar motions to the combs *g*, *g*, and *m*, *m*; which may be applied also to combing goat-hair.

For the purposes of the worsted manufacture, wool should be rendered inelastic to a considerable degree, so that its fibres may form long lines, capable of being twisted into straight level yarn. Mr. Bayliffe, of Kendal, has sought to accomplish this object, first, by introducing into the drawing machine a rapidly revolving wheel, in contact with the front drawing roller, by whose friction the filaments are heated, and at the same time deprived of their curling elasticity; secondly, by employing a movable regulating roller, by which the extent of surface on the periphery of the wheel that the lengths of

wool is to act upon, may be increased or diminished at pleasure, and, consequently, the effect regulated or tempered as the quality of the wool may require; thirdly, the

1549



employment of steam in a rotatory drum, or hollow wheel, in place of the wheel first described, for the purpose of heating the wool, in the process of drawing, in order to facilitate the operation of straightening the fibres.

These objects may be effected in several ways; that is, the machinery may be variously constructed, and still embrace the principles proposed. Fig. 1549. shows one mode: — *a*, is the friction wheel; *b*, the front drawing roller, placed in the drawing frame in the same way as usual; the larger wheel *a*, constituting the lower roller of the pair of front drawing rollers; *c*, and *d*, are the pair of back drawing

rollers, which are actuated by gear connected to the front rollers, as in the ordinary construction of drawing machines, the front rollers moving very considerably faster than the back rollers, and, consequently, drawing or extending the fibres of the sliver of wool, as it passes through between them; *e*, is a guide roller, bearing upon the periphery of the large wheel; *f*, is a tension roller, which presses the fibres of the wool down upon the wheel *a*.

Now, supposing the back rollers *c* and *d* to be turned with a given velocity, and the front roller *b* to be driven much faster, the effect would be, that the fibres of wool constituting the sliver, passing through the machine, would be considerably extended between *b* and *d*, which is precisely the effect accomplished in the ordinary drawing frame; but the wheel *a*, introduced into the machine in place of the lower front drawing roller, being made to revolve much faster than *b*, the sliver of wool extended over the upper part of its periphery from *b*, to the tension roller *f*, will be subjected to very considerable friction from the contact; and, consequently, the natural curl of the wool will be taken out, and its elasticity destroyed, which will enable the wool to proceed in a connected roving down to the spindle or flyer *A*, where it becomes twisted or spun into a worsted thread.

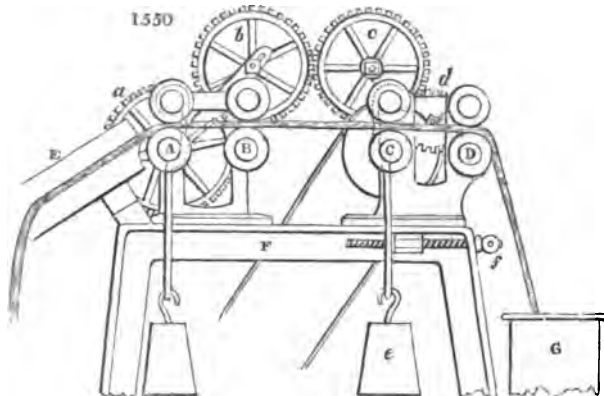
In order to increase or diminish the extent to which the fibres of wool are spread over the periphery of the wheel *a*, a regulating roller is adapted to the machine, as shown at *g*, in place of the tension roller *f*. This regulating roller *g*, is mounted by its pivots in bearings on the circular arms *h*, shown by dots. These circular arms turn loosely upon the axle of the wheel *a*, and are raised or depressed by a rack and a winch, not shown in the figure; the rack taking into teeth on the periphery of the circular arms. It will hence be perceived, that by raising the circular arms, the roller *g*, will be carried backward, and the fibres of wool pressed upon the periphery of the wheel to a greater extent. On the contrary, the depression of the circular arms will draw the roller *g*, forward, and cause the wool to be acted upon by a smaller portion of the periphery of the wheel *a*, and consequently subject it to less friction.

When it is desired to employ steam for the purpose of heating the wool, the wheel *a*, is formed as a hollow drum, and steam from a boiler, in any convenient situation, is conveyed through the hollow axle to the interior of the drum, which, becoming heated by that means, communicates heat also to the wool, and thereby destroys its curl and elasticity.

Breaking-frame. — Here the slivers are *planked*, or spliced together, the long end of one to the short end of another; after which they are drawn out and extended by the rollers of the breaking-frame. A sketch of this machine is given in *fig. 1550*. It consists of four pairs of rollers *A, B, C, D*. The first pair *A*, receives the wool from the inclined trough *x*, which is the planking-table. The slivers are unrolled, parted, and hung loosely over a pin, in reach of the attendant, who takes a sliver, and lays it flat in the trough, and the end is presented to the rollers *A*, which being in motion, will draw the wool in; the sliver is then conducted through the other rollers, as shown in the figure: when the sliver has passed half through, the end of another sliver is placed upon the middle of the first, and they pass through together; when this second is passed half through, the end of a third is applied upon the middle of it, and in this way the short slivers produced by the combing are joined into one regular and even sliver.

The lower roller *c* receives its motion from the mill, by means of a pulley upon the end of its axis, and an endless strap. The roller which is immediately over it, is borne down by a heavy weight, suspended from hooks, which are over the pivots of the upper roller. The fourth pair of rollers *D*, moves with the same velocity as *c*, being turned

by means of a small wheel upon the end of the axis of the roller *c*, which turns a wheel of the same size upon the axis of the roller *b*, by means of an intermediate wheel *d*, which makes both rollers turn the same way round. The first and second pairs of



rollers, *A* and *B*, move only one-third as quick as *c* and *D*, in order to draw out the sliver between *B* and *C* to three times the length it was when put on the planking-table. The slow motion of the rollers *A*, is given by a large wheel *a*, fixed upon the axis of the roller *A*, and turned by the intermediate cog-wheels *b*, *c*, and *d*; the latter communicates between the rollers *c* and *D*. The pinions on the rollers *c* and *D* being only one-third the size of the wheel *a*, *c* and *D* turn three times as fast as *A*, for *b*, *c*, and *d*, are only intermediate wheels. The rollers *B* turn at the same rate as *A*. The upper roller *e* is loaded with a heavy weight, similar to the rollers *A*; but the other rollers, *A* and *D*, are no further loaded than the weight of the rollers.

The two pairs of rollers *A*, *B*, and *C*, *D*, are mounted in separate frames; and that frame which contains the third and fourth pairs *c*, *D*, slides upon the cast-iron frame *F*, which supports the machine, in order to increase or diminish the distance between the rollers *B* and *C*. There is a screw *f*, by which the frame of the rollers is moved, so as to adjust the machine according to the length of the fibre of the wool. The space between *B* and *C* should be rather more than the length of the fibres of the wool. The intermediate wheels *b* and *c*, are supported upon pieces of iron, which are movable on centres; the centre for the piece which supports the wheel *b* is concentric with the axis of the roller *A*; and the supporting piece for the wheel *c* is fitted on the centre of the wheel *d*. By moving these pieces the intermediate wheels *b* and *c* can be always kept in contact, although the distance between the rollers is varied at times. By means of this breaking-frame, the perpetual sliver, which is made up by planking the sliver together, is equalized, and drawn out three times in length, and delivered into the can *G*.

Drawing-frame.— Three of these cans are removed to the drawing-frame, which is similar to the breaking-frame, except that there is no planking-table *K*. There are five sets of rollers, all fixed upon one common frame *F*, the breaking-frame, which we have described, being the first. As fast as the sliver comes through one set of rollers, it is received into a can, and then three of these cans are put together, and passed again through another set of rollers. In the whole, the wool must pass through the breaker and four drawing-frames before the roving is begun. The draught being usually four times at each operation of drawing, and three times in the breaking, the whole will be $3 \times 4 \times 4 \times 4 \times 4 = 768$; but to suit different sorts of wool, the three last drawing-frames are capable of making a greater draught, even to five times, by changing the pinions; accordingly the draught will be $3 \times 4 \times 5 \times 5 \times 5 = 1500$ times.

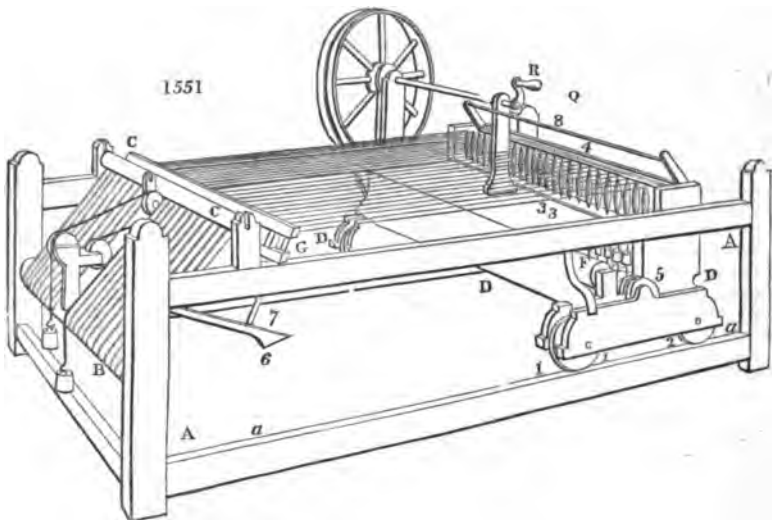
The size of the sliver is diminished by these repeated drawings, because only three slivers are put together, and they are drawn out four times; so that, in the whole, the sliver is reduced to a fourth or a ninth of its original bulk.

The breaking-frame and drawing-frame which are used when the slivers are prepared by the combing-machines, are differently constructed; they have no planking-table, but receive three of the perpetual slivers of the combing-machine from as many tin cans, and draw them out from ten to twelve times. In this case, all the four rollers contribute to the operation of drawing: thus the second rollers *B*, move $\frac{1}{3}$ times as fast as the rollers *A*; the third rollers *c*, move 8 times as fast as *A*; and the fourth rollers *D*, move $10\frac{1}{2}$ times as fast as *A*. In this case, the motion is given to the different rollers by means of bevelled wheels, and a horizontal axis, which extends across the ends of all the four rollers, to communicate motion from one pair of rollers to another.

There are three of these systems of rollers, which are all mounted on the same frame; and the first one through which the wool passes, is called the breaking-frame;

peatedly through this machine, both before and after it is dyed; the second last time for the purpose of blending the different sorts together, and the last for imbuing the fibres intimately with oil. The oiled wool is next subjected to a first carding operation called *scribbling*, whereby it is converted into a broad thin fleece or lap, as cotton is by the breaker-cards of a cotton mill. The woollen lap is then worked by the cards proper, which deliver it in a narrow band or sliver. By this process the wool expands greatly in all its dimensions; while the broken or short filaments get entangled by crossing in every possible direction, which prepares them for the fulling operation. See *Carding*, under *COTTON MANUFACTURE*.

The *slubbing machine*, or *billy*, reduces the separate rolls of *cardings* into a continuous slightly twisted spongy cord, which is sometimes called a *roving*. *Fig. 1551.* is a per-



spective representation of the slubbing machine in most common use. *A, A,* is the wooden frame; within which is the movable carriage *D, D,* which runs upon the lower side rails at *a, a,* on friction wheels at *1, 2,* to make it move easily backwards and forwards from one end of the frame to the other. The carriage contains a series of steel spindles, marked *3, 3,* which receive rapid rotation from a long tin drum *r,* by means of a series of cords passing round the pulley or whorl of each spindle. This drum, 6 inches in diameter, is covered with paper, and extends across the whole breadth of the carriage. The spindles are set nearly upright in a frame, and about 4 inches apart; their under ends being pointed conically, turn in brass sockets called steps, and are retained in their position by a small brass collet, which embraces each spindle at about the middle of its length. The upper half of each spindle projects above the top of the frame. The drum revolves horizontally before the spindles, having its axis a little below the line of the whorls; and receives motion, by a pulley at one of its ends, from an endless band which passes round a wheel *x,* like the large domestic wheel formerly used in spinning wool by hand, and of similar dimensions. This wheel is placed upon the outside of the main frame of the machine, and has its shafts supported by upright standards upon the carriage *D.* It is turned by the spinner placed at *Q,* with his right hand applied to a winch *x,* which gives motion to the drum, and thereby causes the spindles to revolve with great velocity.

Each spindle receives a soft cylinder or carding of wool, which comes through beneath a wooden roller *c, c,* at the one end of the frame. This is the *billy roller*, so much talked of in the controversies between the operatives and masters in the cotton factories, as an instrument of cruel punishment to children, though no such machine has been used in cotton mills for half a century at least. These woollen rolls proceed to the series of spindles, standing in the carriage, in nearly a horizontal plane. By the alternate advance and retreat of the carriage upon its railway, the spindles are made to approach to, and recede from, the roller *c,* with the effect of drawing out a given length of the soft cord, with any desired degree of twist, in the following manner:—

The carding rolls are laid down straight, side by side, upon the endless cloth, strained in an inclined direction between two rollers, one of which is seen at *x,* and the

other ones behind it. One carding is allotted to a spindle; the total number of cards in one machine being from 50 to 100. The roller *c*, of light wood, presses gently with its weight upon the cardings, while they move onwards over the endless cloth, with the running out of the spindle carriage. Immediately in front of the said roller, there is a horizontal wooden rail or bar *a*, with another beneath it, placed across the frame. The carding is conducted through between these two bars, the movable upper one being raised to let any aliquot portion of the roll pass freely. When this bar is again let down, it pinches the spongy carding fast; whence this mechanism is called the clasp. It is in fact the *close*, originally used by Hargreaves in his cotton-jenny. The movable upper rail *a*, is guided between sliders, and a wire *7*, descends from it to a lever *c*. When the spindle carriage *n, d*, is wheeled close home to the billy roller, a wheel *5*, lifts the end *6* of the lever, which, by the wire *7*, raises the upper bar or rail *a*, so as to open the clasp, and release all the card rolls. Should the carriage be now drawn a little way from the clasp bars, it would tend to pull a corresponding length of the cardings forward from the inclined plane *n, c*. There is a small catch, which lays hold of the upper bar of the clasp *a*, and hinders it from falling till the carriage has receded to a certain distance, and has thereby allowed from 7 to 8 inches of the cardings to be taken out. A stop upon the carriage then comes against the catch, and withdraws it; thus allowing the upper rail to fall and pinch the carding, while the carriage, continuing to recede, draws out or stretches that portion of the roll which is between the clasp and the spindle points. But during this time the wheel has been turned to keep the spindles revolving, communicating the proper degree of twist to the cardings in proportion to their extension, so as to prevent them from breaking.

It might be imagined that the slubbing cords would be apt to coil round the spindles; but as they proceed in a somewhat inclined direction to the clasp, they receive merely a twisting motion, continually slipping over the points of the spindles, without getting wound upon them. Whenever the operative or slubber has given a due degree of twist to the rovings, he sets about winding them upon the spindles into a conical shape, for which purpose he presses down the faller-wire *8*, with his left hand, so as to bear it down from the points of the spindles, and place it opposite to their middle part. He next makes the spindles revolve, while he pushes in the carriage slowly, so as to coil the slubbing upon the spindle into a conical cop. The wire *8*, regulates the winding-on of the whole series of slubbings at once, and receives its proper angle of depression for this purpose from the horizontal rail *4*, which turns upon pivots in its ends, in brasses fixed on the standards, which rise from the carriage *n*. By turning this rail on its pivots, the wire *8* may be raised or lowered in any degree. The slubber seizes the rail *4* in his left hand, to draw the carriage out; but in returning it, he depresses the faller-wire, at the same time that he pushes the carriage before him.

The cardings are so exceedingly tender, that they would readily draw out, or even break, if they were dragged with friction upon the endless cloth of the inclined plane. To save this injurious traction, a contrivance is introduced for moving the apron. A cord is applied round the groove in the middle part of the upper roller, and after passing over pulleys, as shown in the figure, it has a heavy weight hung at the one end, and a light weight at the other, to keep it constantly extended, while the heavy weight tends to turn the rollers with their endless cloth round in such a direction as to bring forward the rovings, without putting any strain upon them. Every time that the carriage is pushed home, the larger weight gets wound up; and when the carriage is drawn out, the greater weight turns the roller, and advances the endless apron, so as to deliver the carding at the same rate as the carriage runs out; but when the proper quantity is delivered, a knot in the rope arrives at a fixed stop, which does not permit it to move any further; while at the same instant the roller *5* quits the lever *6*, and allows the upper rail *a*, of the clasp to fall, and pinch the carding fast; the wheel *x*, being then set in motion, makes the spindles revolve; and the carriage being simultaneously drawn out, extends the slubbings while under the influence of twisting. In winding up the slubbings, the operative must take care to push in the carriage, and to turn the wheel round at such rates that the spindles will not take up faster than the carriage moves on its railway, or he would injure the slubbings. The machine requires the attendance of a child, to bring the cardings from the card-engine, to place them upon the sloping feed-cloth, and to join the ends of the fresh ones carefully to the ends of the others newly drawn under the roller. Slubbings intended for warp-yarn must be more twisted than those for weft; but each must receive a degree of torsion relative to the quality of the wool and of the cloth intended to be made. In general, however, no more twist should be given to the slubbings than is indispensable for enabling them to be drawn out to the requisite slenderness without breaking. This twist forms no part of the twist of the finished yarn, for the slubbing will be twisted in the contrary direction, when spun afterwards in the jenny or mule.

I may here remark, that various machines have been constructed of late years for

making continuous card-ends, and slubbings, in imitation of the carding and roving of the *CORROW MANUFACTURE*; to which article I therefore refer my readers. The wool slubbings are now spun into yarn, in many factories, by means of the mule. Indeed, I have seen in France the finest yarn, for the *mousseline-de-laine* fabrics, beautifully spun upon the self-actor mule of Sharp and Roberts.*

Tentering. — When the cloth is returned from the fulling-mill (which see), it is stretched upon the tenter-frame, and left in the open air till dry.

In the woollen manufacture, as the cloth suffers, by the operation of the fulling-mill, a shrinkage of its breadth to well nigh one-half, it must at first be woven of nearly double its intended width when finished. Superfine six-quarter broad cloths must therefore be turned out of the loom twelve-quarters wide.

Burling is the name of a process, in which the dried cloth is examined minutely in every part, freed from knots or uneven threads, and repaired by sewing any little rents, or inserting sound yarns in the place of defective ones.

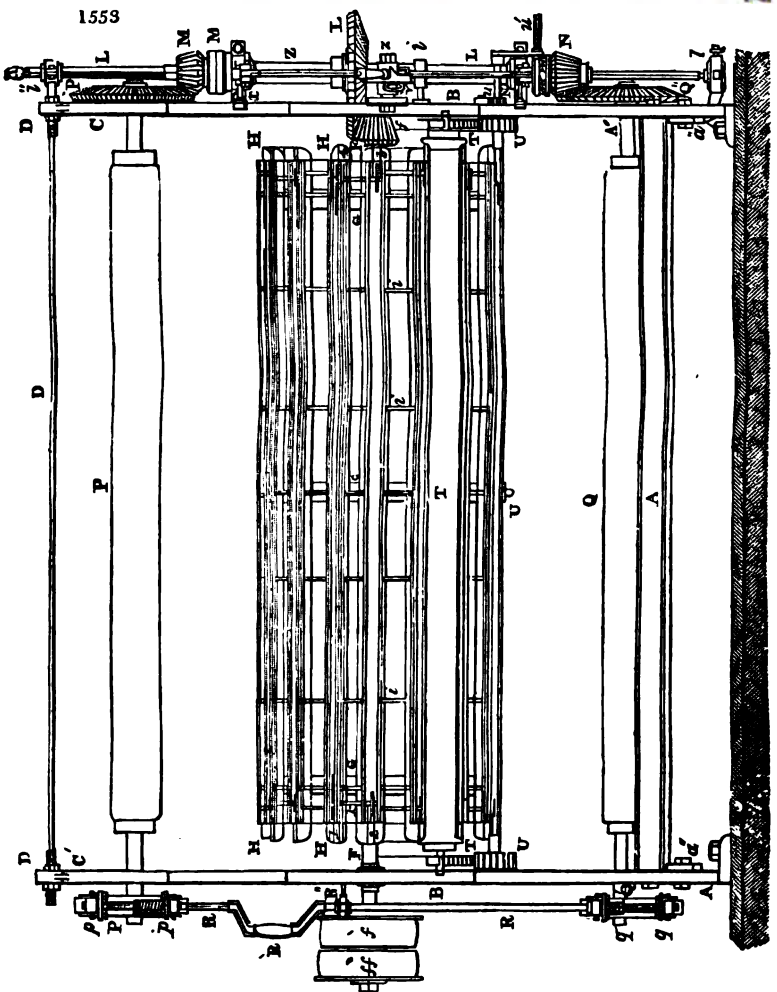
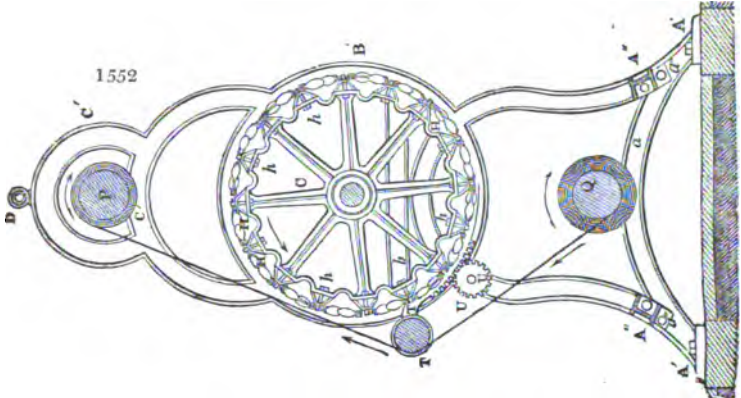
Teasling. — The object of this operation is to raise up the loose filaments of the woollen yarn into a nap upon one of the surfaces of the cloth, by scratching it either with thistle-heads, called teasels, or with teasling-cards or brushes, made of wire. The natural teasels are the balls which contain the seeds of the plant called *Dipsacus ful-lorum*; the scales which form the balls, project on all sides, and end in sharp elastic points, that turn downwards like hooks. In teasling by hand, a number of these balls are put into a small wooden frame, having crossed handles, eight or ten inches long; and when thus filled, form an implement not unlike a curry-comb, which is used by two men, who seize the teasel-frame by the handles, and scrub the face of the cloth, hung in a vertical position from two horizontal rails, made fast to the ceiling of the workshop. First, they wet the cloth, and work three times over, by strokes in the direction of the warp, and next of that of the weft, so as to raise all the loose fibres from the felt, and to prepare it for shearing. In large manufactories, this dressing operation is performed by a machine called a gig-mill, which originally consisted, and in most places still consists, of a cylinder bristled all over with the thistle-heads, and made to revolve rapidly while the cloth is drawn over it in a variety of directions. If the thistle be drawn in the line of the warp, the points act more efficaciously upon the weft, being perpendicular to its softer spun yarns. Inventors who have tried to give the points a circular or oblique action between the warp and the weft, proceed apparently upon a false principle, as if the cloth were like a plate of metal, whose substance could be pushed in any direction. Teasling really consists in drawing out one end of the filaments, and leaving the body of them entangled in the cloth; and it should seize and pull them perpendicularly to their length, because in this way it acts upon the ends, which being least implicated, may be most readily disengaged.

When the hooks of the thistles become clogged with flocks of wool, they must be taken out of the frame or cylinder, and cleaned by children with a small comb. Moisture, moreover, softens their points, and impairs their teasling powers; an effect which needs to be counterbalanced, by taking them out, and drying them from time to time. Many contrivances have, therefore, been proposed, in which metallic teasels of an unchangeable nature, mounted in rotatory machines, driven by power, have been substituted for the vegetable, which being required in prodigious quantities, become sometimes excessively scarce and dear in the clothing districts. In 1818, several schemes of that kind were patented in France, of which those of M. Arnold-Merick, and of MM. Taurin frères, of Elboeuf, are described in the 16th volume of *Brevets d'Invention expirés*. Mr. Daniell, cloth manufacturer in Wilts, renewed this invention under another form, by making his rotatory cards with two kinds of metallic wires, of unequal lengths; the one set, long, thin, and delicate, representing the points of the thistle; the other, shorter, stiffer, and blunter, being intended to stay the cloth, and to hinder the former from entering too far into it. But none of these processes have succeeded in discarding the natural teasel from the most eminent manufactories.

The French government purchased, in 1807, the patent of Douglas, an English mechanist, who had, in 1802, imported into France, the best system of gig-mills then used in the west of England. A working set of his machines having been placed in the *Conservatoire des Arts*, for public inspection, they were soon introduced into most of the French establishments, so as generally to supersede teasling (*lainage*) by hand. A description of them was published in the third volume of the *Brevets d'Invention*. The following is an outline of some subsequent improvements: —

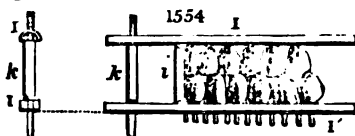
1. As it was imagined that the seesaw action of the hand operative was in some respects more effectual than the uniform rotation of a gig-mill, this was attempted to be imitated by an alternating movement.

* See this admirable machine fully described and delineated in my *Cotton Manufacture of Great Britain*, vol. II.

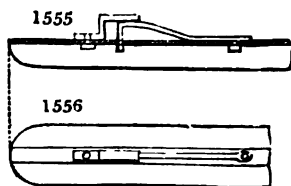


band, with six semi-cylindrical hollows, separated alternately by as many portions of the periphery. One of these three wheels is placed in the middle of the shaft *r*, and the other two, towards its extremities. Their size may be judged of, from inspection of *fig. 1552*. After having set them so that all their spokes or radii correspond exactly, the 16 sides *s*, are made fast to the 16 portions of the periphery, which correspond in the three wheels. These sides are made of sheet iron, curved into a gutter form, *fig. 1552*., but rounded off at the end, *fig. 1553*., and each of them is fixed to the three fellos of the wheels by three bolts *k*. The elastic part of the plate iron allows of their being sufficiently well adjusted, so that their flat portions furthest from the centre may lie pretty truly on a cylindrical surface, whose axis would coincide with that of the shaft *r*.

Between the 16 sides there are 16 intervals, which correspond to the 16 hollowings of each of the wheels. Into these intervals are adjusted, with proper precautions, 16 frames bearing the teasels which are to act upon the cloth. These are fitted in as follows:—Each has the shape of a rectangle, of a length equal to that of the drum, but their breadth only large enough to contain two thistle-heads set end to end, thus making two rows of parallel teasels throughout the entire length, (see the contour in *fig. 1552*.) A portion of the frame is represented in *fig. 1554*. The large side *z*, against which the tops of the teasels rest, is hollowed out into a semi-cylinder, and its opposite side is cleft throughout its whole length, to receive the tails of the teasels, which are seated and compressed in it. There are, moreover, cross-bars *t*, which serve to maintain the sides of the frame *z*, at an invariable distance, and to form short compartments for keeping the thistles compact. The



ends are fortified by stronger bars *k, k*, with projecting bolts to fasten the frames between the ribs. The distance of the sides of the frame *z, z'*, ought to be such, that if a frame be laid upon the drum, in the interval of two ribs, the side *z* will rest upon the inclined plane of one of the ribs, and the side *z'* upon the inclined plane of the other, (see *fig. 1552*.); while at the same time the bars *k*, of the two ends of the frame, rest upon the flat parts of the ribs themselves. This point being secured, it is obvious, that if the ends of the bars *k* be stopped, the frame will be made fast.



But they need not be fixed in a permanent manner, because they must be frequently removed and replaced. They are fastened by the clamp, (*figs. 1555, 1556*.), which is shut at the one end, and furnished at the other with a spring, which can be opened or shut at pleasure. 2 and 4, in *fig. 1553*. (near the right end of the shaft *r*), shows the place of

the clamp, *figs. 1555, 1556*. The bar of the right hand is first set in the clamp, by holding up its other end; the frame is then let down into the left-hand clamp.

The cloth is wound upon the lower beam *q*, *fig. 1552*.; thence it passes in contact with a wooden cylinder *τ*, turning upon an axis, and proceeds to the upper beam *r*, on to which it is wound: by a contrary movement, the cloth returns from the beam *r* to *q*, over the cylinder *τ*; and may thus go from the one to the other as many times as shall be requisite. In these successive circuits it is presented to the action of the teasels, under certain conditions. In order to be properly teased, it must have an equal tension throughout its whole breadth during its traverse; it must be brought into more or less close contact with the drum, according to the nature of the cloth, and the stage of the operations; sometimes being a tangent to the surface, and sometimes embracing a greater or smaller portion of its contour, it must travel with a determinate speed, dependent upon the velocity of the drum, and calculated so as to produce the best result: the machine itself must make the stuff pass alternately from one winding beam to the other.

In *fig. 1553*., before the front end of the machine, there is a vertical shaft *L*, as high as the framework, which revolves with great facility, in the bottom step *l*, the middle collet *F*, and top collet *F'*, in the prolongation of the stretcher *d*. Upon this upright shaft are mounted—1. a bevel wheel *l'*; 2. an upper bevel pinion *x*, with its boss *x'*; 3. a lower bevel pinion *x*, with its boss *x'*. The bevel wheel *l'* is keyed upon the shaft *l*, and communicates to it the movement of rotation which it receives from the pinion *f*, with which it is in gear; but the pinion *f*, which is mounted upon the shaft *r* of the drum, participates in the rotation which this shaft receives from the prime mover, by means of the fast rigger-pulley *f'*. The upper pinion *x* is independent upon the shaft *z*; that is to say, it may be slid along it, up and down, without being driven by it; but it may be turned in an indirect manner by means of six curved teeth, projecting from

its bottom, and which may be rendered active or not, at pleasure; these curved teeth, and their intervals, correspond to similar teeth and intervals upon the top of the boss x' , which is dependent, by feathered indentations, upon the rotation of x , though it can slide freely up and down upon it. When it is raised, therefore, it comes into gear with x . The pinion x , and its boss, have a similar mode of being thrown into and out of gear with each other. The bosses x' and x'' , ought always to be moved simultaneously, in order to throw one of them into gear, and the other out of gear. The shaft z serves to put the cloth in motion, by means of the bevel wheels r' and q' , upon the ends of the beams r , q , which take into the pinions x and x' .

The mechanism destined to stretch the cloth is placed at the other end of the machine, where the shafts of the beams r , q , are prolonged beyond the frame, and bear at their extremities r' and q' , armed each with a brake. The beam r (*fig. 1552.*), turns in an opposite direction to the drum; consequently the cloth is wound upon r , and unwound from q . If, at the same time as this is going on, the handle x' , of the brake-shaft, be turned so as to clasp the brake of the pulley q' , and release that of the pulley r' , it is obvious that a greater or smaller resistance will be occasioned in the beam q , and the cloth which pulls it in unwinding, will be able to make it turn only when it has acquired the requisite tension; hence it will be necessary, in order to increase or diminish the tension, to turn the handle x' a little more or a little less in the direction which clasps the brake of the pulley q' ; and as the brake acts in a very equable manner, a very equable tension will take place all the time that the cloth takes to pass. Besides, should the diminution of the diameter of the beam q , render the tension less efficacious in any considerable degree, the brake would need to be unclamped a very little, to restore the primitive tension.

When the cloth is to be returned from the beam r , to the beam q , z must be lowered, to put the shaft z out of gear above, and in gear below; then the cloth-beam q , being driven by that vertical shaft, it will turn in the same direction as the drum, and will wind the cloth round its surface. In order that it may do so, with a suitable tension, the pulley q' must be left free, by clasping the brake of the pulley r' , so as to oppose an adequate resistance.

The cloth is brought into more or less close contact with the drum as follows:— There is for this purpose a wooden roller τ , against which it presses in passing from the one winding beam to the other, and which may have its position changed relatively to the drum. It is obvious, for example, that in departing from the position represented in *fig. 1552.*, where the cloth is nearly a tangent to the drum, if the roller τ be raised, the cloth will cease to touch it; and if it be lowered, the cloth will, on the contrary, embrace the drum over a greater or less portion of its periphery. For it to produce these effects, the roller is borne at each end, by iron gudgeons, upon the heads of an arched rack τ'' (*fig. 1552.*), where it is held merely by pins. These racks have the same curvature as the circle of the frame, against which they are adjusted by two bolts; and by means of slits, which these bolts traverse, they may be slid upwards or downwards, and consequently raise or depress the roller τ . But to graduate the movements, and to render them equal in the two racks, there is a shaft u , supported by the uprights of the frame, and which carries, at each end, pinions u' , u'' , which work into the two racks τ' , τ'' : this shaft is extended in front of the frame, upon the side of the head of the machine (*fig. 1553.*), and there it carries a ratchet wheel w , and a handle w' . The workman, therefore, requires merely to lay hold of the handle, and turn it in the direction of the ratchet wheel, to raise the racks, and the roller τ , which they carry; or to lift the click or catch, and turn the handle in the opposite direction, when he wishes to lower the roller, so as to apply the cloth to a larger portion of the drum.

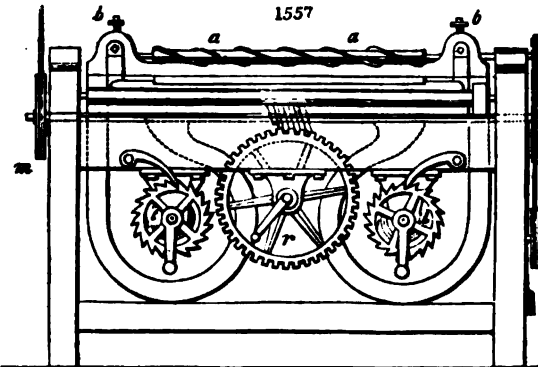
CLOTH CROPPING.

Of machines for cropping or shearing woollen cloths, those of Lewis and Davis have been very generally used.

Fig. 1557. is an end view, and *fig. 1558.* is a side view, of Lewis's machine for shearing cloth from list to list. *Fig. 1559.* is an end view of the carriage, with the rotatory cutter detached from the frame of the machine, and upon a larger scale: a , is a cylinder of metal, on which is fixed a triangular steel wire; this wire is previously bent round the cylinder in the form of a screw, as represented at a , α , in *fig. 1557.*, and, being hardened, is intended to constitute one edge of the shear or cutter.

The axis of the cylindrical cutter a , turns in the frame b , which, having proper adjustments, is mounted upon pivots c , in the standard of the travelling carriage d , d ; and e , is the fixed or ledger blade, attached to a bar f , which constitutes the other edge of the cutter; that is, the stationary blade, against which the edges of the rotatory cutter act; f and g , are flat springs, intended to keep the cloth (shown by dots) up against the cutting edges. The form of these flat springs f , g , is shown at *figs. 1560.* and *1561.*,

as consisting of plates of thin metal cut into narrow slips (*fig. 1560.*), or perforated with long holes. (*fig. 1561.*) Their object is to support the cloth, which is intended to pass between them, and operate as a spring bed, bearing the surface of the cloth against

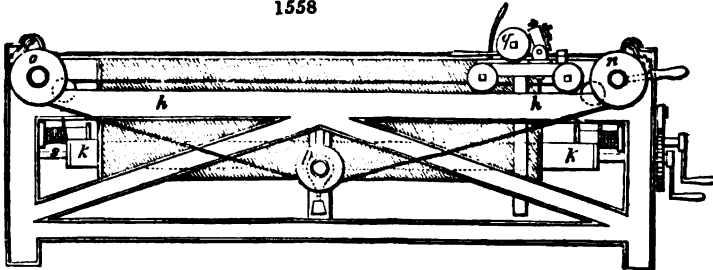


the cutters, so that its pile or nap may be cropped off or shorn as the carriage *d* is drawn along the top rails of the standard or frame of the machine *A, A*, by means of cords.

The piece of cloth to be shorn, is wound upon the beam *k*, and its end is then conducted through the machine, between the flat springs *f* and *g* (as shown in *fig. 1559.*), to the other beam *l*, and is then made fast; the

sides or lists of the cloth being held and stretched by small hooks, called habiting books. The cloth being thus placed in the machine, and drawn tight, is held dis-

1558

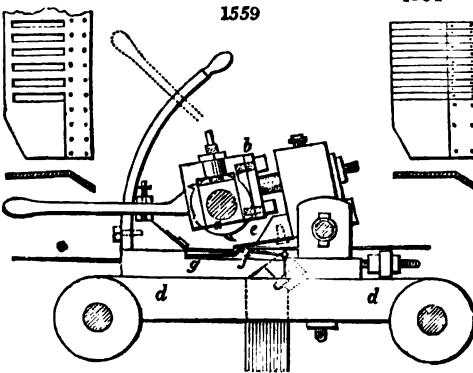


tended by means of ratchets on the ends of the beams *k* and *l*, and palls. In commencing the operation of shearing, the carriage *d*, must be brought back, as in *fig. 1559.*, so

1560

1559

1561



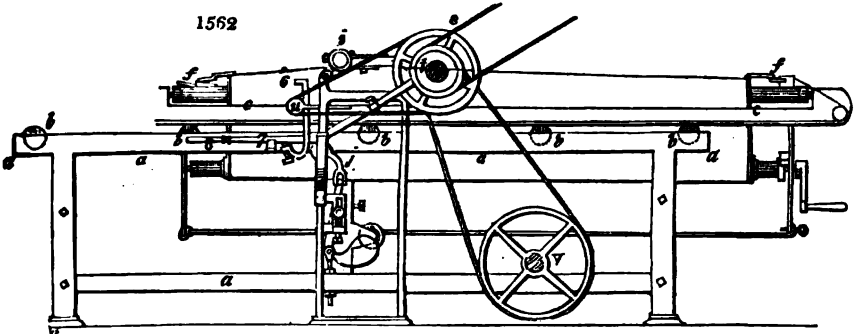
that the cutters shall be close to the list; the frame of the cutters is raised up on its pivots as it recedes, in order to keep the cloth from injury, but is lowered again previously to being put in action. A band or winch is applied to the rigger or pulley *m*, which, by means of an endless cord passed round the pulley *n*, at the reverse end of the axle of *m*, and round the other pulleys *o* and *p*, and the small pulley *q*, on the axle of the cylindrical cutter, gives the cylindrical cutter a very rapid rotatory motion; at the same time a worm, or endless screw, on the axle of *m* and *n*, taking

into the teeth of the large wheel *r*, causes that wheel to revolve, and a small drum *s*, upon its axle, to coil up the cord, by which the carriage *d*, with the cutters *a* and *c*, and the spring bed *f* and *g*, are slowly, but progressively, made to advance, and to carry the cutters over the face of the cloth, from list to list; the rapid rotation of the cutting cylinder *a*, producing the operation of cropping or shearing the pile.

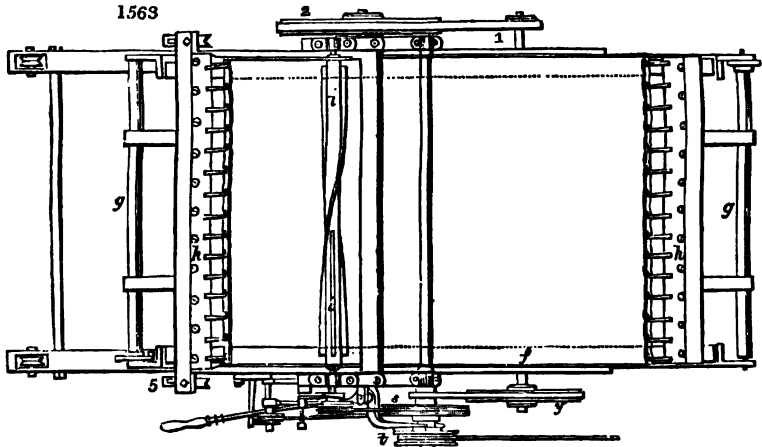
Upon the cutting cylinder, between the spiral blades, it is proposed to place stripes of plush, to answer the purpose of brushes, to raise the nap or pile as the cylinder goes around, and thereby assist in bringing the points of the wool up to the cutters.

The same contrivance is adapted to a machine for shearing the cloth lengthwise.

Fig. 1562. is a geometrical elevation of one side of Mr. Davis's machine. *Fig. 1563.* a plan or horizontal representation of the same, as seen in the top; and *fig. 1564.* a section taken vertically across the machine near the middle, for the purpose of displaying the working parts more perfectly than in the two preceding figures. These three figures represent a complete machine in working condition, the cutters being worked by a rotatory motion, and the cloth so placed in the carriage as to be cut from list to list. *a, a, a,* is a frame or standard, of wood or iron, firmly bolted together by cross braces at the ends and in the middle. In the upper side-rails of the standard,



there is a series of axles carrying anti-friction wheels *b, b, b,* upon which the side-rails *c, c,* of the carriage or frame that bears the cloth runs, when it is passing under the cutters in the operation of shearing. The side-rails *c, c,* are straight bars of iron, formed with edges *v,* on their under sides, which run smoothly in the grooves of the rollers *b, b, b.* These side-rails are firmly held together by the end stretchers *d, d.*

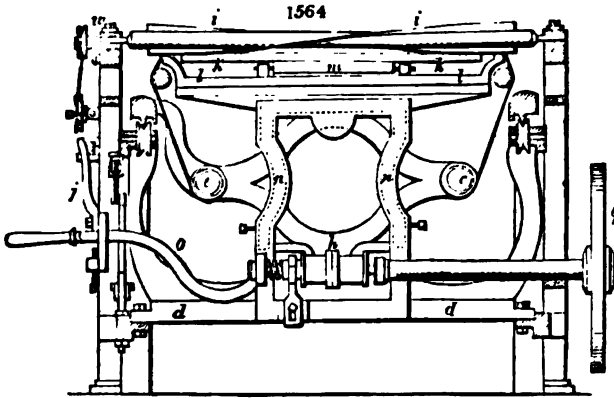


The sliding frame has attached to it the two lower rollers *e, e,* upon which the cloth intended to be shorn is wound; the two upper lateral rollers *f, f,* over which the cloth is conducted and held up; and the two end rollers *g, g,* by which the habiting rails *h, h,* are drawn tight.

In preparing to shear a piece of cloth, the whole length of the piece is, in the first place, tightly rolled upon one of the lower rollers *e,* which must be something longer than the breadth of the cloth from list to list. The end of the piece is then raised, and passed over the top of the lateral rollers *f, f,* whence it is carried down to the other roller *e,* and its end or farral is made fast to that roller. The books of the habiting rails *h, h,* are then put into the lists, and the two lower rollers *e, e,* with the two end rollers *g, g,* are then turned, for the purpose of drawing up the cloth, and straining it tight, which tension is preserved by ratchet wheels attached to the ends of the respective rollers, with palls dropping into their teeth. The frame carrying the cloth, is now slid along upon the top standard rails by hand, so that the list shall be brought

nearly up to the cutter *i, i*, ready to commence the shearing operation; the bed is then raised, which brings the cloth up against the edges of the shears.

The construction of the bed will be seen by reference to the cross section *fig. 1564*.



It consists of an iron or other metal roller *k, k*, turned to a truly cylindrical figure, and covered with cloth or leather, to afford a small degree of elasticity. This roller is mounted upon pivots in a frame *l, l*, and is supported by a smaller roller *m, m*, similarly mounted, which roller *m, m*, is intended merely to prevent any bending or depression of the central part

of the upper roller or bed *k, k*, so that the cloth may be kept in close contact with the whole length of the cutting blades.

In order to allow the bed *k* to rise and fall, for the purpose of bringing the cloth up to the cutters to be shorn, or lowering it away from them after the operation, the frame *l, l*, is made to slide up and down in the grooved standard *s, s*, the movable part enclosed within the standard being shown by dots. This standard *s*, is situated about the middle of the machine, crossing it immediately under the cutters, and is made fast to the frame *a*, by bolts and screws. There is a lever *o*, attached to the lower cross-rail of the standard, which turns upon a fulcrum-pin, the extremity of the shorter arm of which lever acts under the centre of the sliding-frame, so that by the lever *o*, the sliding-frame, with the bed, may be raised or lowered, and when so raised, be held up by a spring catch *j*.

It being now explained by what means the bed which supports the cloth is constructed, and brought up, so as to keep the cloth in close contact with the cutters, while the operation of shearing is going on; it is necessary, in the next place, to describe the construction of the cutters, and their mode of working; for which purpose, in addition to what is shown in the first three figures, the cutters are also represented detached, and upon a larger scale, in *fig. 1565*.

In this figure is exhibited a portion of the cutters in the same situation as in *fig. 1559*; and alongside of it is a section of the same, taken through it at right angles to the former; *p*, is a metallic bar or rib, somewhat of a wedge form, which is fastened to the top part of the standard *a, a*, seen best in *fig. 1558*.

To this bar a straight blade of steel *g*, is attached by screws, the edge of which stands forward even with the centre or axis of the cylindrical cutter *i*, and forms the ledger blade, or lower fixed edge of the shears. This blade remains stationary, and is in close contact with the pile or nap of the cloth, when the bed *k*, is raised, in the manner above described.

The cutter or upper blade of the shears, is formed by inserting two or more strips of plate steel *r, r*, in twisted directions, into grooves in the metallic cylinder *i, i*, the edges of which blades *r*, as the cylinder *i* revolves, traverse along the edge of the fixed or ledger blade *g*, and by their obliquity produce a cutting action like shears; the edges of the two blades taking hold of the pile or raised nap, as the cloth passes under it, shaves off the superfluous ends of the wool, and leaves the face smooth.

Rotatory motion is given to the cutting cylinder *i*, by means of a band leading from the wheel *s*, which passes round the pulley fixed on the end of the cylinder *i*, the wheel *s* being driven by a band leading from the rotatory part of a steam-engine, or any other first mover, and passed round the rigger *t*, fixed on the axle *s*. Tension is given to this band by a tightening pulley *u*, mounted on an adjustable sliding-piece *v*, which is secured to the standard by a screw; and this rigger is thrown in and out of gear by a clutch-box and lever, which sets the machine going, or stops it.

In order to give a drawing stroke to the cutter, which will cause the piece of cloth to be shorn off with better effect, the upper cutter has a slight lateral action, produced

by the axle of the cutting cylinder being made sufficiently long to allow of its sliding laterally about an inch in its bearings; which sliding is effected by a cam w , fixed at one end. This cam is formed by an oblique groove, cut round the axle, (see w , *fig.* 1565.) and a tooth x , fixed to the frame or standard which works in it, as the cylinder revolves. By means of this tooth, the cylinder is made to slide laterally, a distance equal to the obliquity of the groove w , which produces the drawing stroke of the upper shear. In order that the rotation of the shearing cylinder may not be obstructed by friction, the tooth x , is made of two pieces, set a little apart, so as to afford a small degree of elasticity.

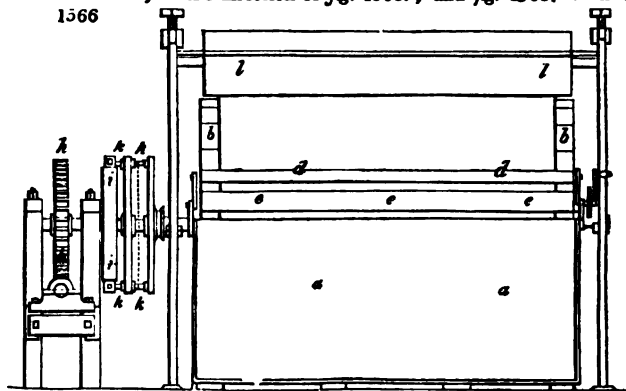
The manner of passing the cloth progressively under the cutters is as follows:— On the axle of the wheel s , and immediately behind that wheel, there is a small rigger, from which a band passes to a wheel y , mounted in an axle turning in bearings on the lower side-rail of the standard a . At the reverse extremity of this axle, there is another small rigger l , from which a band passes to a wheel 2 , fixed on the axle 3 , which crosses near the middle of the machine, seen in *fig.* 1226. Upon this axle there is a sliding pulley 4 , round which a cord is passed several times, whose extremities are made fast to the ends of the sliding carriage d ; when, therefore, this pulley is locked to the axle, which is done by a clutch box, the previously described movements of the machine cause the pulley 4 to revolve, and by means of the rope passed round it, to draw the frame, with the cloth, slowly and progressively along under the cutters.

It remains only to point out the contrivance whereby the machinery throws itself out of gear, and stops its operations, when the edge of the cloth or list arrives at the cutters.

At the end of one of the habiting rails k , there is a stop affixed by a nut and screw 5 , which, by the advance of the carriage, is brought up and made to press against a lever 6 ; when an arm from this lever 6 , acting under the catch 7 , raises the catch up, and allows the hand-lever 8 , which is pressed upon by a strong spring, to throw the clutch-box 10 , out of gear with the wheel 8 ; whereby the evolution of the machine instantly ceases. The lower part of the lever 6 , being connected by a joint to the top of the lever j , the receding of the lever 6 , draws back the lower catch j , and allows the sliding frame l, l , within the bed k , to descend. By now turning the lower rollers e, e , another portion of the cloth is brought up to be shorn; and when it is properly habited and strained, by the means above described, the carriage is slid back, and, the parts being all thrown into gear, the operation goes on as before.

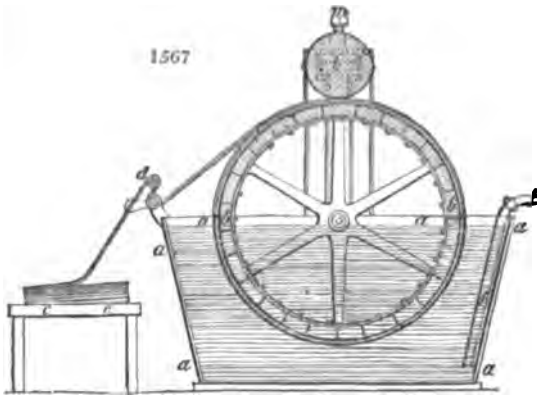
Mr. Hirst's improvements in manufacturing woollen cloths, for which a patent was obtained in February, 1830, apply to that part of the process where a permanent lustre is given usually by what is called roll-boiling; that is, stewing the cloth, when tightly wound upon a roller, in a vessel of hot water or steam. As there are many disadvantages attendant upon the operation of roll-boiling, such as injuring the cloths, by overheating them, which weakens the fibre of the wool, and also changes some colours, he substituted, in place of it, a particular mode of acting upon the cloths, by occasional or intermitted immersion in hot water, and also in cold water, which operations may be performed either with or without pressure upon the cloth, as circumstances may require.

The apparatus which he proposes to employ for carrying on his improved process, is shown in the accompanying drawing. *Fig.* 1566. is a front view of the apparatus, complete, and in working order; *fig.* 1567. is a section, taken transversely through the middle of the machine, in the direction of *fig.* 1568.; and *fig.* 1568. is an end view



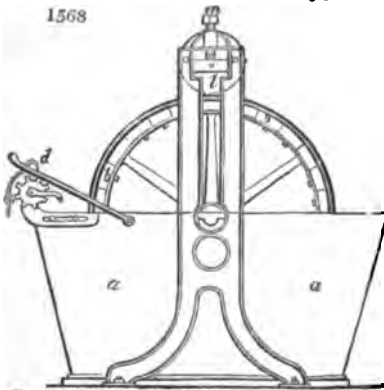
of the same; a, a, a , is a vessel or tank, made of iron or wood, or any other suitable material: sloping at the back and front, and perpendicular at the ends. This

tank must be sufficiently large to admit of half the diameter of the cylinder or drum *b, b*, being immersed into it, which drum is about four feet diameter, and about six feet long, or something more than the width of the piece of cloth intended to be operated



upon. This cylinder or drum *b, b*, is constructed by combining segments of wood cut radially on their edges, secured by screw-bolts to the rims of the iron wheels, having arms, with an axle passing through the middle. The cylinder or drum being thus formed, rendered smooth on its periphery, and mounted upon its axle in the tank, the piece of cloth is wound upon it as tightly as possible, which is done by placing it in a heap upon a stool, as at *c*, *Fig. 1567.*, passing its end over and between the tension-rollers *d, e*, and then securing it to the drum, the cloth is progressively drawn from the heap, between the tension-rollers, which are confined by a pall and ratchet, on to the periphery of the drum, by causing the drum to revolve upon its axis, until the whole piece of cloth is tightly wound upon the drum; it is then bound round with canvas or other wrappers, to keep it secure.

If the tank has not been previously charged with clean and pure water, it is now filled to the brim, as shown at *fig. 1567.*, and opening the stopcock of the pipe



f, which leads from a boiler, the steam is allowed to blow through the pipe, and discharge itself at the lower end, by which means the temperature of the water is raised in the tank to about 170° Fahr. Before the temperature of the water has got up, the drum is set in slow rotatory motion, in order that the cloth may be uniformly heated throughout; the drum making about one rotation per minute. The cloth, by immersion in the hot water, and passing through the cold air, in succession, for the space of about eight hours, gets a smooth soft face, the texture not being rendered harsh, or otherwise injured, as is frequently the case by roll-boiling.

Uniform rotatory motion to the drum is shown in *fig. 1566.*, in which *g* is an endless screw or worm, placed horizontally, and driven by a steam-engine or any other first mover employed in the factory. This endless screw takes into the teeth of, and drives, the vertical wheel *h*, upon the axle of which the coupling-box *i, i*, is fixed, and, consequently, continually revolves with it. At the end of the shaft of the drum, a pair of sliding clutches *k, k*, are mounted, which, when projected forward, as shown by dots in *fig. 1566.*, produce the coupling or locking of the drum-shaft to the driving wheel, by which the drum is put in motion; but on withdrawing the clutches *k, k*, from the coupling-box *i, i*, as in the figure, the drum immediately stands still.

After operating upon the cloth in the way described, by passing it through hot water for the space of time required, the hot water is to be withdrawn by a cock at the bottom, or otherwise, and cold water introduced into the tank in its stead; in which cold water the cloth is to be continued turning, in the manner above described, for the space of twenty-four hours, which will perfectly fix the lustre that the face of the cloth has acquired by its immersion in the hot water, and leave the pile or nap, to the touch, in a soft silky state.

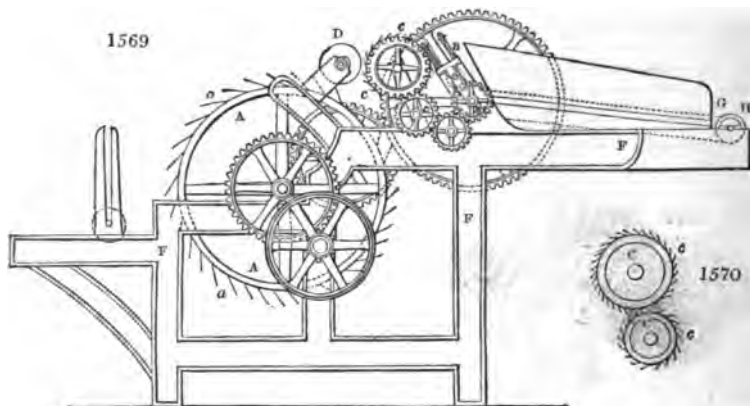
In the cold-water operation he sometimes employs a heavy pressing roller *l*, which, being mounted in slots in the frame or standard, revolve with the large drum, rolling over the back of the cloth as it goes round. This roller may be made to act upon the

cloth with any required pressure, by depressing the screws *m, m*, or by the employment of weighted levers, if that should be thought necessary.

Pressing is the last finish of cloth to give it a smooth level surface. The piece is folded backwards and forwards in yard lengths, so as to form a thick package on the board of a screw or hydraulic press. Between every fold sheets of glazed paper are placed to prevent the contiguous surfaces of the cloth from coming into contact; and at the end of every twenty yards, three hot iron plates are inserted between the folds, the plates being laid side by side, so as to occupy the whole surface of the folds. Thin sheets of iron not heated are also inserted above and below the hot plates to moderate the heat. When the packs of cloth are properly folded, and piled in sufficient number in the press, they are subjected to a severe compression, and left under its influence till the plates get cold. The cloth is now taken out and folded again, so that the creases of the former folds may come opposite to the flat faces of the paper, and be removed by a second pressure. In finishing superfine cloths, however, a very slight pressure is given with iron plates but moderately warmed. The satiny lustre and smoothness given by strong compression with much heat is objectionable, as it renders the surface apt to become spotted and disfigured by rain.

Ross's patent improvements in wool combing machinery, March 13. 1851.—The first improvements described have relation to the machine for forming the wool into sheets of a nearly uniform thickness, technically known as the "sheeter," and consist chiefly in combining with the ordinary sheeting drum or cylinder rollers, designated, from their resemblance to porcupine quills, porcupine rollers; these rollers having their teeth or quills set in rows, and the rows of one roller gearing or taking into the spaces between the rows of the other.

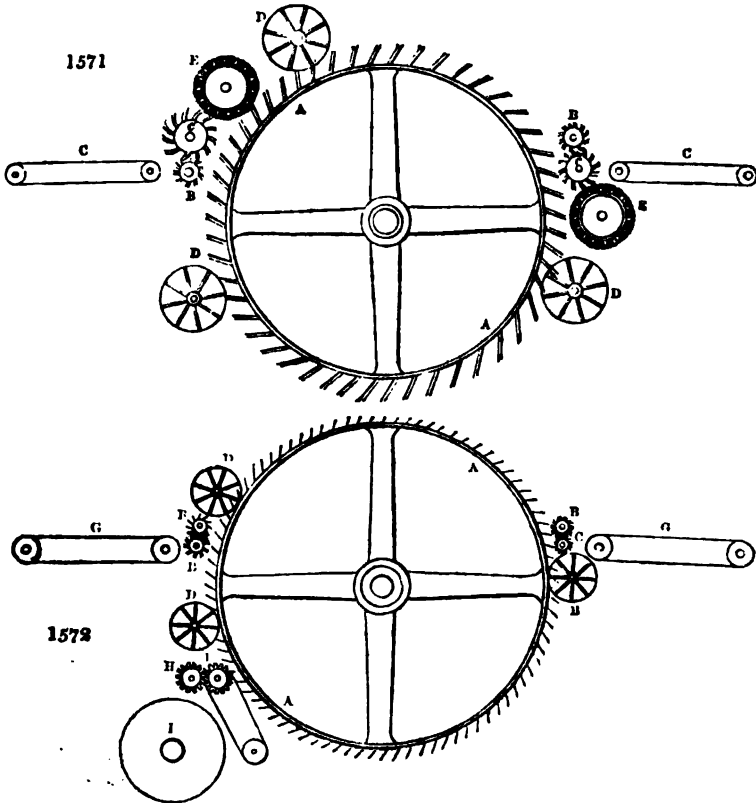
Fig. 1569. is an elevation of a sheeting machine thus constructed:—*r r* is the general



frame work upon which the several working parts of the machine are mounted. *A* is the main or sheeting drum or cylinder, which is studded with rows of comb or "porcupine" teeth *a, a, a*, the length and fineness of which are varied according to the length of the staple of the wool or other material to be operated upon. Instead of the rows consisting each of a single set of teeth, two, three, or more sets may be combined together. The number of wires which may be placed on one line should vary with the quality of the wool or other material. In long staple machines, the number may vary from four to ten or more, and in short staple machines from five to twenty and more per inch. *B, B*, are two fluted feed-rollers. *C, C*, two porcupine combing rollers, by which the wool is partly combed while passing from the feed rollers to the surface of the sheeting drum; an end elevation of the porcupine combing rollers on an enlarged scale is given at *fig. 1570*. The teeth *c, c*, are set in rows, and the rows of one roller take or gear into the spaces between the rows of the other. *n* is a grooved guide roller for preventing the wool or other material escaping the combing action. The wool or other material is laid by the attendant evenly upon the upper surface of an endless web *o*, which works over the under feed rollers, and a plain roller *u*, which is mounted in bearings on the front of the machine. The feed-rollers gradually supply the wool thus spread upon the endless web to the two porcupine combing rollers, where it is partly combed and separated, and being so prepared, it is laid hold of by the teeth of the sheeting drum, by which it is still further drawn out on account of the greater velocity with which the surface of the sheeting drum travels. When a sufficient quantity of the wool or other material has been thus

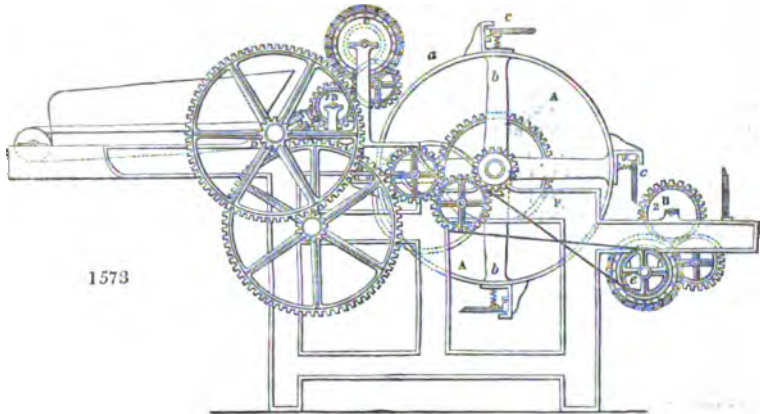
collected on the surface of the drum, it is removed by the attendant passing a hooked rod across the surface of the drum, and raising up one end of the sheet, when the whole may be easily stripped off and removed, being then in a fit state for being supplied to the comb-filling machine, next to be described.

A modification of this sheeting machine is represented in *figs.* 1571, 1572, which differs



from it in this, that it is fed from both ends. In this modification a double set of feeding rollers is employed, so that the machine may be fed from both ends. These rollers are grooved and gear into porcupine combing rollers similar to those before described, which are followed by brush cylinders or grooved guide rollers. A is the sheeting drum as before; B, b, the fluted feed-rollers. C, c, the porcupine combing rollers, which gear into the fluted ones; D, d, are the grooved guide rollers; F, F, are brush cylinders, which may in the case of long work be dispensed with; G, G, are the endless webs upon which the wool is laid. The framing and gearing by which the several parts are put in motion are omitted in the drawings, for the purpose of clearly exhibiting the more important working parts of the machine. The arrangement of sheeting machines just described, is so far as regards the employment of a fluted feed roller in conjunction with a porcupine combing roller, and grooved guide roller, is more especially applicable to sheeting fine short wool, but may also be applied with advantage to wool or other material of a longer staple. In the case of fine short wool, the sheet may be drawn off by means of rollers, in the manner represented in *fig.* 1572. H, H, are the drawing or straightening rollers, and I the receiving rollers. During the operation of drawing the wool and winding it on the receiving roller, the sheeting cylinder must have a motion imparted to it in the reverse direction.

The next head of Mr. Ross's specification embraces several improvements in comb-filling machines, which have for their common object the partial combing of the wool while it is in the course of being filled into the combs. We select for exemplification what the patentee regards as the best of these arrangements: *fig.* 1573. is a side elevation of a comb-filling machine as thus improved. A, A, is a skeleton drum, which is composed



of two rings *a a*, affixed to the arms *b, b*, which last are mounted upon the main shaft of the machine, which has its bearings upon the general frame *r, r*; *s¹, s²* are the porcupine combing rollers, and *c¹, c²* brushes by which the porcupine combing rollers are cleansed from the wool that collects upon them, and by which the wool is again delivered to the combs *e, e*; *n, n*, are the feed-rollers, and *x* an endless web which runs over the lower feed-roller and the plain roller *c*, which is situated at the front of the machine; *h, h*, are the driving pulleys, by which the power is applied to the machine, and *l, l, l*, the wheel gearing by which motion is communicated to the different parts. The wool which has undergone the process of sheeting in the machine first described is spread upon the endless web *x*, and in passing between the feed-rollers, and between or under or over the porcupine combing rollers, is taken hold of by the combs *e, e*, as they revolve, and, being drawn under the first porcupine roller *s¹* and the brush *c¹*, the continued revolution of the drum and combs causes the wool to be brought into contact with the other porcupine combing roller *s²* and brush *c²*. As the combs get filled, the wool is thus continuously being brought under the action of the porcupine combing rollers and brushes; and each new portion of the wool taken up is instantly combed out. For some purposes the combing will be found carried so far by this operation that the wool will require no further preparation previous to being formed into slivers in the machine just described, and which is calculated for filling the combs and combing the wool or other fibrous material, when the staple is some considerable length (say from 4 to 16 inches), there are two porcupine comb rollers with their brushes employed; but I do not confine myself to that number, as in some cases a single porcupine combing roller and brush will be found sufficient for the purpose of facilitating the process of combing and filling the combs; three or more rollers and brush cylinders may be used with advantage; such as where the staple is short, or where the fibrous material operated upon is very close, and separated with difficulty.

Mr. Ross next describes some improvements in the combing machine of his invention patented in 1841, and now extensively used. The following general description will indicate with sufficient distinctness to those familiar with the machine, the nature of the improvements.

“First. I give to the saddle combs in the said machine a compound to-and-fro and up-and-down movement, whereby they recede from and advance towards the comb gates, and simultaneously therewith alternately rise and fall, so that each time the comb gates pass the saddle combs, they do so in a different plane, and thus the position of the combs in relation to each other, as well as to the hold they take of the wool or other material, is constantly being changed. Secondly, I employ a fan to lash the wool in the comb gate or flying comb up against the saddle comb, which renders it impossible for the wool to pass by the saddle comb without being acted upon by it. Thirdly, I attach the springs by which the gates are actuated to the lower arms of the combing gates, instead of their being placed parallel to the upright shaft of the machine as formerly, whereby a considerable gain in space and compactness is effected; and, fourthly, I use breaks to prevent the sudden jerk which is caused when the wool in the comb gate leaves its hold of the saddle comb or incline plane, and also to counteract the sudden recoil of the springs by which the comb gates are pressed in when these springs are released from the grip or pressure of the incline plane.”

Mr. Ross concludes with a description of an improved method of beating the combs which has for its object “the economising of fuel, the better heating of the combs, and

the prevention of mistake in removing the combs before they have been a sufficient time exposed to the heat."

The body of the heating box or stove is divided by a partition into two portions, which communicate together at the back or further end of the stove, so that the flame and heated vapours, after having circulated under and along the sides of the two lower comb chambers, ascend into the upper portion of the stove, where they have to traverse along the sides and over the top of the two upper chambers, ultimately escaping into the chimney through a pipe. The length of the heating box, or the chambers, should be about double the length of the combs. The cold combs are inserted at one end, and on being put into their places push the more heated combs towards the other end of the chambers, from which they are removed.

WOOTZ, is the Indian name of steel.

WORSTED and WOOLLEN MANUFACTURE. 312,500 people employed; producing an annual value of 25,000,000*l*. Dewsbury is famous for tearing up old worn cloth and working the woollen stuff into new goods of a cheap description.

Alpaca is an animal of the Llama tribe, inhabiting the mountain region of Peru. The wool or hair is of various shades of black, white, gray, brown, &c., and is remarkable for brightness and lustre, great length of staple, and extreme softness. This wool was brought into general use in this country about 16 years ago, by the Earl of Derby. Since that time the various obstacles in the way of its successful working have been overcome, and the alpaca manufacture now ranks as one of the most important branches of the Bradford worsted stuff trade. The articles produced from alpaca in combination with silk are especially noticeable for their softness and brilliancy. The bulk of the goods, however, is made with cotton warp, and when dyed and finished approach in lustre to silk. The following is the average yearly importation of alpaca wool into England since its first introduction, viz.

| | | Annual. | |
|-------------------|-------|---------|-------------|
| From 1846 to 1840 | - - - | - | 7,000 bales |
| 1841 1845 | - - - | - | 13,000 |
| 1846 1850 | - - - | - | 20,000 |

being supposed to be the ultimate limit of the Peruvian production.

Mohair or goat's wool is produced exclusively in Asia Minor. In its raw state it is superior in lustre to alpaca, and it is wrought into many beautiful fabrics. The importation of this article has increased from 5,621 bales in 1841 to 12,884 in 1850.

WORT, is the fermentable infusion of malt or grains. See BEER, and MALT.

WOULFE'S APPARATUS, is a series of vessels, connected by tubes, for the purpose of condensing gaseous products in water. See ACETIC ACID, *fig. 1.*; also MURLATIC ACID.

X.

XANTHINE, is the name given by Kuhlmann to the yellow dyeing-matter contained in madder.

Y.

YEAST, is the froth of fermenting worts. See BEER and FERMENTATION.

Dr. Lüdersdorff supports the theory that yeast is an organic body, and acts by means of its organs on sugar, in contradistinction to the theories of its action by mere contact, or by its own state of decomposition inducing a similar state in the saccharine solution by the following experiment:—

A portion of yeast was rubbed between ground glass plates until the globules, of which it is composed, could no longer be distinguished by the microscope, and its organic structure therefore was destroyed. An equal portion was exposed, moistened, in a thin layer to the air, whilst the other was being thus treated. Both portions were now mixed separately with equal quantities of grape sugar, dissolved in 10 parts of water, and exposed to a temperature of 95° F. The portion containing the uninjured yeast began to ferment in half an hour, and continued to do so until the whole of the sugar was decomposed. The mutilated yeast did not produce a single gas bubble in the fluid containing it during the whole of this time.

YEAST, ARTIFICIAL. Mix two parts, by weight, of the fine flour of pale barley malt with one part of wheat flour. Stir 50 pounds of this mixture gra-

dually into 100 quarts of cold water, with a wooden spatula, till it forms a smooth pap. Put this pap into a copper over a slow fire; stir it well till the temperature rise to fully 155° to 160°, when a partial formation of sugar will take place, but this sweetening must not be pushed too far; turn out the thinned paste into a flat cooler, and stir it from time to time. As soon as the wort has fallen to 59° Fahr., transfer it to a tub, and add for every 50 quarts of it, 1 quart of good fresh beer-yeast, which will throw the wort into brisk fermentation in the course of 12 hours. This preparation will be good yeast, fit for bakers' and brewers' uses, and will continue fresh and active for 3 days. It should be occasionally stirred.

When beer-barm has become old and flat, but not sour, it may be revived by mixing with every quart of it a small potato, boiled, peeled, and rubbed down into a paste. The mixture is to be placed in a warm situation, where it will speedily show its renewed activity, by throwing up a froth upon its surface. It must be forthwith incorporated with the dough, for the purpose of baking bread. When the barm has become sour, its acid should be neutralised with a little powdered carbonate of soda, and then treated as above, when it will, in like manner, be revived. A bottle of brisk small beer may furnish ferment enough to form, in this way, a supply of good yeast for a small baking.

The German yeast imported into this country in large quantities, and employed by our bakers, in baking cakes, and other *stacy* bread, is made by putting the *waterhefe* (see *BEER, Bavarian*), into thick sacks of linen or hempen yarn, letting the liquid part, or beer, drain away; placing the drained sacks between boards, and exposing them to a gradually increasing pressure, till a mass of a thin cheesy consistence is obtained. This cake is broken into small pieces, which are wrapped in separate linen cloths; these parcels are afterwards enclosed in waxed cloth, for exportation. The yeast cake may also be rammed hard into a pitched cask, which is to be closed air-tight. In this state, if kept cool, it may be preserved active for a considerable time. When this is to be used for beer, the proportion required should be mixed with a quantity of worts at 60° Fahr., and the mixture left for a little to work, and send up a lively froth; when it is quite ready for adding to the cooled worts in the fermenting back.

YEAST, PATENT. Boil 6 ounces of hops in 3 gallons of water 3 hours: strain it off, and let it stand 10 minutes; then add half a peck of ground malt, stir it well up, and cover it over; return the hops, and put the same quantity of water to them again, boiling them the same time as before, straining it off to the first mash; stir it up, and let it remain 4 hours, then strain it off, and set it to work at 90°, with 3 pints of patent yeast; let it stand about 20 hours; take the scum off the top, and strain it through a hair sieve; it will be then fit for use. One pint is sufficient to make a bushel of bread.

YELLOW DYE. (*Teinture jaune, Fr.; Gelbfärben, Germ.*) *Annatto, dyer's-broom (Geniata tinctoria), fustic, fustet, Persian or French berries, quercitron bark, saw-swort (Serratula tinctoria), turmeric, weld, and willow leaves,* are the principal yellow dyes of the vegetable kingdom; *chromate of lead, iron-oxide, nitric acid* (for silk), *sulphuret of antimony, and sulphuret of arsenic,* are those of the mineral kingdom. Under these articles, as also under *CALICO-PRINTING, DYEING, and MORDANTS,* ample instructions will be found for communicating this colour to textile and other fibrous substances. Alumina and oxide of tin are the most approved bases of the above vegetable dyes. A nankin dye may be given with *bablah*, especially to cotton oiled preparatory to the Turkey-red process. See *MADDER*.

YELLOW, KING'S, is a poisonous yellow pigment. See *ARSENIC and ORPIMENT*.

YTTRIA, is a rare earth, extracted from the minerals gadolinite and yttrotalite, being an oxide of the metal yttrium.

Z.

ZAFFRE. See *COBALT*.

ZEDOARY, is the root of a plant which grows in Malubar, Ceylon, &c. It occurs in wrinkled pieces, externally ash-coloured, internally brownish-red; possessed of a fragrant odour, somewhat resembling camphor; and of a pungent, aromatic, bitterish taste. It contains according to Bucholz, 1·42 of volatile oil, of a burning camphorated taste; 3·60 of a soft, bitter, aromatic resin; 11·75 of a bitter aromatic extract, mixed with a little resin and potash-salts; 4·5 of gum; 9 of vegetable mucilage; 3·60 of starch; 8·0 of a starchy extract from the woody fibre, by means of caustic potassa, along with 31·2 of another matter, 12·89 of woody fibre, and 15 of water. According to Morin this root contains besides an azotized substance, analogous to the extract of beef.

ZIMOME, is a principle supposed by Taddei to exist in the gluten of wheat-flour. Its identity is not recognised by later chemists.

ZINC, is a metal of a bluish-white colour, of a considerable lustre when broken across, but easily tarnished by the air; its fracture is hackly, and foliated with small facets, irregularly set. It has little cohesion, and breaks in thin plates before the hammer, unless it has been previously subjected to a regulated process of lamination, at the temperature of from 220° to 300° F., whereby it becomes malleable and retains its malleability and ductility afterwards. On this singular property a patent was taken out by Messrs. Hobson and Sylvester, of Sheffield, many years ago, for manufacturing sheet zinc, for covering the roofs of houses, and sheathing ships; but the low price of copper at that time, and its superior tenacity, rendered their patent ineffective. The specific gravity of zinc varies from 6.9 to 7.2, according to the condensation it has received. It melts under a red heat, at about the 680th or 700th degree of Fahrenheit's scale. When exposed to this heat with contact of air, the metal takes fire, and burns with a brilliant bluish-white light, while a few flocculi, of a woolly-looking white matter, rise out of the crucible, and float in the air. The result of the combustion is a white powder, formerly called flowers, but now oxide of zinc; consisting of 34 of metal, and 8 of oxygen, being their respective prime equivalents; or, in 100 parts, of 81 and 19.

The principal ores of zinc are, the sulphuret called *blende*, and the silicate called *calamine*, and the sparry calamine, or the carbonate.

1. *Blende* crystallizes in the garnet-dodecahedron; its fracture is highly conchoidal; lustre, adamantine; colours, black, brown, red, yellow, and green; transparent or translucent; specific gravity, 4. It is a simple sulphuret of the metal; and, therefore, consists, in its pure state, of 34 of zinc, and 16 of sulphur. It dissolves in nitric acid, with disengagement of sulphuretted hydrogen gas. It occurs in beds and veins, accompanied chiefly by galena, iron pyrites, copper pyrites, and heavy spar. There is a radiated variety found at Praisram, remarkable for containing a large proportion of cadmium. Blende is found in great quantities in Derbyshire and Cumberland, as also in Cornwall.

2. *Calamine*, or silicate of zinc, is divided into two species; the prismatic or electric calamine, and the rhomboïdal; though they both agree in metallurgic treatment. The first has a vitreous lustre, inclining to pearly; colour, white, but occasionally blue, green, yellow, or brown; spec. grav. 3.38. It often occurs massive, and in botroidal shapes. This species is a compound of oxide of zinc with silica and water; and its constituents are—zinc oxide, 66.37; silica, 26.23; water, 7.4; in 100 parts. Reduced to powder, it is soluble in dilute sulphuric or nitric acid, and the solution gelatinizes on cooling. It emits a green phosphorescent light before the blowpipe. The second species, or rhomboïdal calamine, is a carbonate of zinc. Its specific gravity is 4.442, much denser than the preceding. It occurs in kidney-shaped, botroidal, stalactitic, and other imitative shapes; surface generally rough, composition columnar. Massive, with a granular texture, sometimes impalpable; strongly coherent. According to Smithson's analysis, Derbyshire calamine consists of—oxide of zinc, 65.2; carbonic acid, 34.8; which coincides almost exactly with a prime equivalent of the oxide and acid, or $42 + 22 = 64$.

The mineral genus called *cinn-ore*, or red oxide of zinc, is denser than either of the above, its spec. grav. being 5.432. It is a compound of oxide of zinc 88, and oxide of iron and manganese 12. It is found massive, of a granular texture, in large quantities, in several localities in New Jersey. It is set free in several metallurgic processes, and occurs crystallized, in six-sided prisms of a yellow colour, in the smelting works of Königshutte in Silesia, according to Mitscherlich.

The zinc ores of England, like those of France, Flanders, and Silesia, occur in two geological localities.

The first is in veins in the carboniferous or mountain limestone. The blende and the calamine most usually accompany the numerous veins of galena which traverse that limestone; though there are many lead mines that yield no calamine; and, on the other hand, there are veins of calamine alone, as at Matlock, whence a very considerable quantity of this ore is obtained.

In almost every point of England where that metalliferous limestone appears, there are explorations for lead and zinc ores. The neighbourhood of Alston-moor in Cumberland, of Castleton and Matlock in Derbyshire, and the small metalliferous belt of Flintshire, are peculiarly marked for their mineral riches. On the north side of the last county, calamine is mined in a rich vein of galena at Holywell, where it presents the singular appearance of occurring only in the ramifications that the lead vein makes from east to west, and never in those from north to south; while the blende, abundantly present in this mine, is found indifferently in all directions.

The second locality of calamine is in the magnesian limestone formation of the English geologists, the alpine limestone of the French, and the *schstein* of the Germans. The calamine is disseminated through it in small contemporaneous veins, which, running in all directions, form the appearance of a network. These veins have commonly a thickness of only a few inches; but in certain cases they extend to four feet,

in consequence of the union of several small ones into a mass. The explorations of calamine in the magnesian limestone, are situated chiefly on the flanks of the Mendip Hills, a chain which extends in a north-west and south-east direction, from the canal of Bristol to Frôme. The calamine is worked mostly in the parishes of Phipham and Roborough, as also near Rickford and Broadfield-Doron, by means of a great multitude of small shafts. The miners pay, for the privilege of working, a tax of 1*l.* sterling per annum to the Lords of the Treasury; and they sell the ores, mixed with a considerable quantity of carbonate of lime, for 1*l.* per ton, at Phipham, after washing it slightly in a sieve. They are despatched to Bristol, where they receive a new washing, in order to separate the galena.

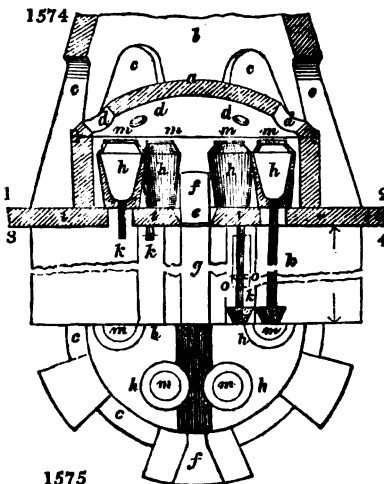
OF THE SMELTING OF THE ORES OF ZINC.

The greater part of the zinc works are situated in the neighbourhood of Birmingham and Bristol. The manufacture of brass, which has been long one of the staple articles of these towns, was probably the cause of the introduction of this branch of industry, at the period when brass began to be made by the direct union of copper with metallic zinc instead of calamine. A few zinc furnaces exist also in the neighbourhood of Sheffield, amid the coal-pits surrounding that town. Bristol and Birmingham derive their chief supply of ores from the Mendip Hills and Flintshire: and Sheffield, from Alston-moor.

The calamine, freed from galena by sorting with the hand, is calcined before its introduction into the smelting-furnaces, by being exposed, coarsely bruised, in reverberatory ovens, 10 feet long, and 8 broad, in a layer 6 inches thick. In some establishments the calcination is omitted, and the calamine, broken into pieces about the size of a pigeon's egg, is mixed with its bulk of small coal.

Zinc is smelted in England, likewise from blende (sulphuret of zinc). This ore, after being washed, and broken into pieces of the size of a filbert, was sold a few years ago at the mine of Holywell for 3*l.* a ton, or half the price of calamine. It is roasted, without any other preparation, in reverberatory furnaces; which are about 8 feet wide, and 10 long: the distance between the roof and the sole being 30 inches, and the height of the fire bridge 18. The layer of blende, which is placed on the hearth, is about 4 or 5 inches thick; and it is continually stirred up with rakes. One ton of it requires for roasting four tons of coals; and it suffers a loss of 30 per cent. The operation takes from 10 to 12 hours. The mixture of reducing consists of one-fourth part of the desulphuretted oxide, one-fourth of calcined calamine, and one-half part of charcoal; which affords commonly 30 per cent. of zinc.

The English furnaces for smelting zinc ores are sometimes quadrangular, sometimes round; the latter form being preferable. They are mounted with from 6 to 8 crucibles or pots (see *fig. 1574.*), arched over with a cupola *a*, placed under a conical chimney *b*, which



serves to give a strong draught, and to carry off the smoke. In this cone there are as many doors *c, c, c,* as there are pots in the furnace; and an equal number of vents *d, d, d,* in the cupola, through which the smoke may escape, and the pots may be set. In the surrounding wall there are holes for taking out the pots when they become unserviceable; after the pots are set, these holes are bricked up. The pots are heated to ignition in a reverberatory furnace before being set, and are put in by means of iron tong machinery supported upon two wheels, as is the case with glass-house pots. *e,* is the grate; *f,* the door for the fuel; *g,* the ash-pit. The pots *h, h, h,* have a hole in the centre of their bottom, which is closed with a wooden plug, when they are set charged with calamine, mixed with one-seventh of coal; which coal prevents the mixture from falling through the orifice, when the heat rises and consumes the plug. The sole of the hearth *i,* upon which the crucibles stand, is perforated

under each of them, so that they can be reached from below; to the bottom orifice of the pot, when the distillation begins, a long sheet-iron pipe *k,* is joined, which dips at its end into a water-vessel *l,* for receiving in drops the condensed vapours of the zinc. The pot is charged from above, through an orifice in the lid of the pot, which is left open after

the firing, till the bluish colour of the flame shows the volatilization of the metal ; immediately whereupon the whole is covered with a fire-tile *m*. The iron tubes are apt to get obstructed during the distillation, and must therefore be occasionally cleared out with a red-hot rod. When the distillation is finished, the iron pipes must be removed; the coaly and other contents of the pot cleared away. A pot lasts about four months upon an average. Five distillations may be made in the course of 14 days, in which from 6 to 10 tons of calamine may be worked up, and from 22 to 24 tons of coals consumed, with a product of two tons of zinc. The metal amounts to from 25 to 40 per cent. of the ore.

1, 2, is the level of the upper floor ; 3, 4, level of the lower ceiling of the lower floor.

Fig. 1575., ground plan on the level of 1, 2 : only one-half is here shown.

The zinc collected in this operation, is in the form of drops, and a very fine powder mingled with some oxide. It must be melted in an iron pot or boiler, set in a proper furnace; and the oxide is skimmed off the surface, to be returned into the crucibles. The metal is, lastly, cast into square bars or ingots.

The crucibles are discharged at the end of each operation, by withdrawing the condenser, breaking with a rake the piece of charcoal which shuts their bottom, and then emptying them completely, by shaking their upper part. In replacing the condenser-pipe *k* (see second pot from the right hand, fig. 1574.), the flange at its top is covered with a ring of loam-lute, pressed against the conical bottom of the crucible, and secured in its place by means of two parallel rods *o, o*, which can be clamped by screws projecting horizontally from the vertical tunnel. See their places, indicated by two open dots near *o, o*.

A smelter and two labourers are employed in conducting a furnace; who make, with a mixture of equal parts of fire-clay, and cement of old pounds finely ground, the pots or crucibles, which last about four months. Five charges are made in 15 days; these work up from 6 to 10 tons of calamine, consume from 22 to 24 tons of coals, and produce 2 tons of zinc, upon an average. The following estimate of prices was made a few years ago :—

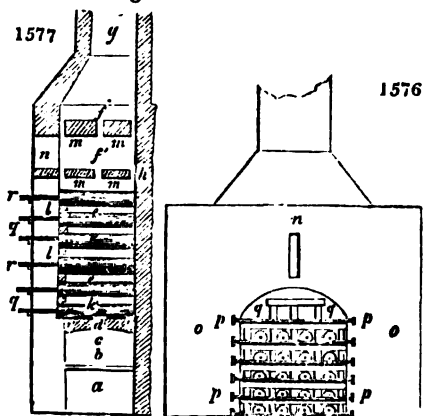
| | £ | s. | d. |
|---|---|----|--------|
| 3 tons of calamine, at 6 <i>l</i> . | - | - | 18 0 0 |
| 24 ditto coal, at 5 <i>s</i> . | - | - | 6 0 0 |
| A smelter, at 2 guineas a week | - | - | 2 0 0 |
| Two labourers, each at 4 <i>s</i> . per day | - | - | 2 16 0 |
| Incidental expenses | - | - | 1 0 0 |

29 18 0

The calamine of Alston-moor, used at Sheffield, is not so rich ; it produces at most only 25 per cent. of zinc. The coals are laid down at a cost of 5*s*. 8*d*. per ton ; and the calamine laid down there 5*l*. ; whence the zinc will amount to 32*l*. 14*s*. per ton. The considerable importations of zinc from Belgium and Germany, for some years back, have caused a considerable fall in its price.

At Lüttich, where the calamine of Altenberg, near Aix-la-Chapelle, is smelted, a reduction furnace, containing long horizontal earthen tubes, is employed. The roasted calamine is finely ground, and mixed with from one-third to two-thirds its volume of coke or charcoal, broken to pieces the size of nuts.

Fig. 1576. represents this zinc furnace in elevation; and fig. 1577. in a vertical section through the middle. From the hearth



there are 22 tubes altogether in one furnace. At their two ends these tubes rest

to the bottom of the chimney it is 9 feet high, and the chimney itself is 18 or 20 feet high. *a*, is the ash-pit ; *b*, the grate ; *c*, the fireplace ; *d*, the hearth ; *e, e*, the laboratory ; *f*, the upper arch, which closes in the laboratory ; *f'*, the second arch, which forms the hood cap of the furnace ; *g*, the chimney ; *h*, the fire-wall, which rests against a supporting wall of the smelting-house. Through the vaulted hearth the flame of the fire draws through ten flues *i, i*, two placed in one line ; betwixt these 5 pairs of draught openings, upon the sole of the hearth, the undermost earthen tubes *h*, immediately rest. The second and third rows of tubes *h, h*, lie in a parallel direction over each other, at about one inch apart ; in the sixth row there are only two tubes ; *s* o that

upon fire-tiles, which form, with the side-walls, a kind of chequer-work *l, l*. The tubes are 4 feet long, 4 to 5 inches in diameter within, $\frac{1}{4}$ of an inch thick. The fire, which arrives at the laboratory through the flues *i, i*, plays round the tubes, and passes off through the apertures *m, m*, in both arches of the furnace, into the chimney. *n*, is an opening in the front wall between the two arches, which serves to modify the draught, by admitting more or less of the external air.

The two slender side walls *o, o*, of the furnace, are a foot distant from the chequer-work, so that on the horizontal iron bars *g, g*, supported by the hooks *p, p*, the iron receivers *r, r*, may have room to rest at their fore part. These receivers are conical pipes of cast-iron, $1\frac{1}{2}$ foot long, posteriorly $1\frac{1}{2}$ inch, and anteriorly 1 inch wide at the utmost. After the earthen tubes have been filled with the ore to be smelted, these conical pipes are luted to them in a slightly slanting position. These cones last no more than three weeks; and are generally lengthened with narrow-mouthed wrought-iron tubes, to prevent the combustion of the zinc, by contact of air. When the furnace is in activity, a blue flame is to be seen at the mouths of all these pipes. Every two

hours the liquefied metal is raked out into a shovel placed beneath; and in 12 hours the charge is distilled; after which the tubes are cleared out, and re-charged. 100 pounds of metallic zinc are the product of one operation. It is remelted at a loss of 10 per cent., and cast into moulds for sale.

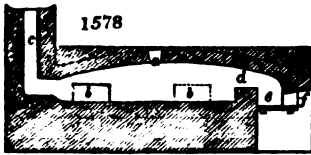
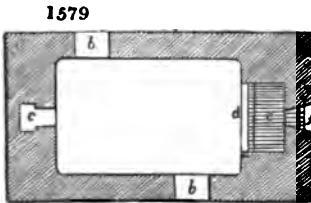
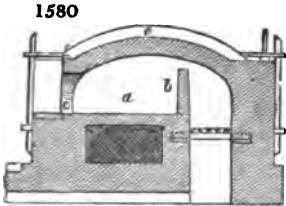


Fig. 1578, is a longitudinal section of the furnace for calcining calamine in Upper Silesia; *fig. 1579*, is a ground plan of the furnace. *a*, is the orifice in the vault or dome, for the introduction of the ore; *b, b*, apertures in the side-walls, shut with doors, through which the matter may be turned over; *c*, the chimney; *d*, the fire-bridge; *e*, the grate; *f*, the feed opening of the fire, the fuel being pitcoal. The calamine is stirred about every hour; and after being well calcined during 5 or 6 hours, it is withdrawn; and a new charge is put in. These Silesian furnaces admit of 30

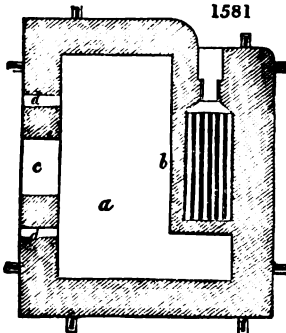


cwt. at a time; and for roasting every 100 cwt., 15 Prussian bushels of fuel, equal to 23 English bushels, are employed.

These calcining furnaces are sometimes built alongside of the zinc smelting-furnaces, and are heated by the waste flame of the latter. The roasting is performed in the Netherlands in shafts, like small blast iron-furnaces, called *schachtoven*.



The hearth *a*, in *figs. 1580, 1581*, is constructed for working with 5 muffles, one of which is long and four short. The muffles are made upon moulds, of fire-clay mixed with ground potsherds. The receivers are stoneware bottles. The grate is 10 inches beneath the level of the hearth. *d*, the fire-bridge, is proportionally high, to diminish the force of the flame upon the hearth, that it may not strike the muffles. *c*, is the opening through which the muffles are put in and taken out; during the firing it is partly filled with bricks, so that the smoke and flame may escape between them; *d, d*, are openings for adjusting the positions of the muffles; *e, e*, cross hoops of iron, to strengthen the brick arch; *f*, is a bed of sand under the sole of the hearth. During the first two days, the fire is applied under the grating; the heat must be very slowly raised to redness, at which pitch it must be maintained during two days. From 8 to 10 days are required for the firing of the muffles.

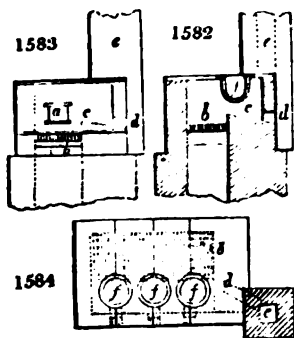


The furnace shown in *figs. 1582, 1583, 1584*, is for the melting of the metallic zinc. *Fig. 1583*, is a front view; *fig. 1582*, a transverse section; *fig. 1584*, a view from above; *a*, is the fire-door; *b*, the grate; *c*, the fire-bridge; *d*, the flue; *e*, the chimney;

f, f, f, cast-iron melting-pots, which contain each about 10 cwt. of the metal. The heat is moderated by the successive addition of pieces of cold zinc. The inside of the pots should be coated with loam, to prevent the iron being attacked by the zinc. When the

zinc is intended to be laminated, it should be melted with the lowest possible heat, and poured into hot moulds.

When the zinc ores contain cadmium, this metal distils over in the form of brown oxide, with the first portions, being more volatile than zinc.



Under BRASS and COPPER, the most useful alloys of zinc are described. The sulphate, vulgarly called white vitriol, is made from the sulphuret, by roasting it gently, and then exposing it upon sloping terraces to the action of air and moisture, as has been fully detailed under SULPHUR or IRON. The purest sulphate of zinc is made by dissolving the metal in dilute sulphuric acid, digesting the solution over some of the metal, filtering, evaporating, and crystallizing.

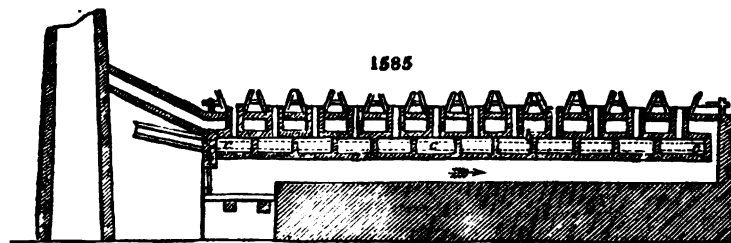
Sulphate of zinc is added as a drier to japan varnishes.

The ordinary zinc found in the market is never pure; but contains lead, cadmium, arsenic, copper, iron, and carbon; from some of which it may be freed in a great degree by distillation; but even after this process it retains a little lead, with all the arsenic and cadmium. The separation of the latter is described under CADMIUM. Zinc, free from other metals, may be obtained by distilling a mixture of charcoal and its subcarbonate, precipitated from the crystallized sulphate by carbonate of soda. By holding a porcelain saucer over the flame of hydrogen produced from the action of dilute sulphuric acid upon any sample of the zinc of commerce, the presence of arsenic in it may be made manifest by the deposit of a gray film of the latter metal. Antimony, however, produces a somewhat similar effect to arsenic.

Zinc is extensively employed for making water-cisterns, baths, spouts, pipes, plates for the zincographer, for voltaic batteries, slings for fire-works, covering roofs, and a great many architectural purposes, especially in Berlin; because this metal, after it gets covered with a thin film of oxide or carbonate, suffers no further change by long exposure to the weather. One capital objection to zinc as a roofing material is its combustibility.

Chloride of zinc has been recently used with great advantage as an escharotic for removing cancerous tumours, and healing various ill-constituted ulcers. It, as also the nitrate, forms an ingredient in the resist pastes for the pale blues of the indigo vat.

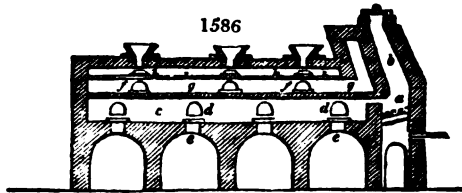
Mr. Nicholas Troughton, of Swansea, obtained a patent in May, 1839, for improvements in the manufacture of this metal. His invention relates to the application of a peculiar apparatus in roasting the ores, and in smelting the zinc. *Fig. 1585.*



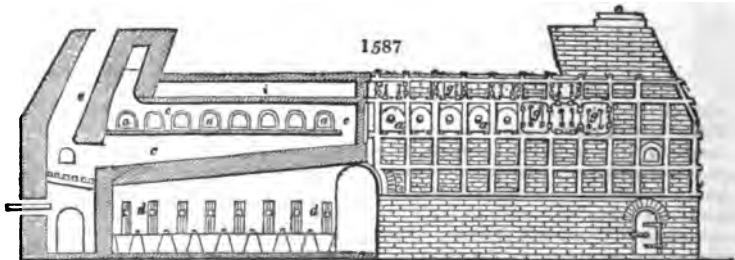
represents the section of a series of retorts for calcining zinc ores, arranged and constructed according to this invention. The retorts shown in this figure are composed of a series of fire-tiles or parallelogram slabs. *a, a, a,* are the slabs or tiles, which constitute the bottoms of the retorts; *b, b,* are the slabs, which constitute the upper surfaces or tops of the retorts; and *c, c,* are slabs, placed vertically, to produce the sides of the retorts. The back ends of the retorts are closed by similar tiles or slabs, having a hole through them for the passage of the vapours evolved from the ores; these vapours are conveyed in any direction by the flue at that end, and being thus separated from the products of combustion, may be separately acted on, according to either of the patentee's former inventions, which treat of the separated vapours of copper ores in the process of calcining or roasting such ores; or the separated products of the ore may be allowed to pass into the atmosphere. The patentee states, that by treating zinc ores in furnaces or retorts, such as are above described, considerable saving of fuel will result, and the zinc ore will be more evenly roasted or calcined.

The front ends of the retorts are closed by means of tiles or doors, having a small hole or opening in each, for the passage of atmospheric air; and the holes may be closed, or more or less open, according to the object required. The retorts are charged through the hoppers above, which have proper slides to close the openings into the retorts; the quantity charged into each retort being sufficient to cover the lower surface thereof two or three inches deep. During the operation the ore must be raked from time to time, to change the surfaces, and the retorts should be kept to a moderate red heat.

The second part of this invention relates to an arrangement of apparatus or furnace for calcining zinc ores, wherein the ore is subjected to the direct action of the products of combustion. *Fig. 1586.* shows a longitudinal section of the furnace, which is so con-



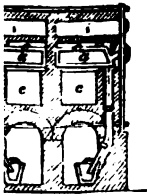
structed that while one portion of the zinc ore is being heated in a manner similar to the working of an ordinary calcining surface, other zinc ore is going through a preparatory process by the heat that has passed away from the ore which is undergoing the completing process of calcining. This furnace may be heated by a separate fire, to burn by blast or by draft; or the flue from the smelting furnace may be conducted into the entrance of this furnace, and the otherwise waste heat of the smelting furnace will be thus brought into useful application for calcining or roasting of zinc ore; and this part of the invention is applicable, whether it be applied to the furnace, or to the retorts herein-before explained, and will be found a means of saving much fuel in the processes of obtaining zinc from ore. *a, fig. 1586.*, represents the furnace, which is suitable for blast, and a constant supply of fuel is kept up in the chamber *b*, there being a close cover, with a sand-joint. *c*, is the bed or floor on which the ore is spread, in like manner to an ordinary reverberatory furnace; the ore is stirred about on the floor by passing the ordinary rakes or instruments through the openings, *d, d*; and when the process has been sufficiently carried on, the ore is discharged through the openings *e, e*, which at other times remain closed by fire-tiles. The heat of the fire, and the flame thereof, passing in contact with the ore on the floor or bed, *c*, also acts on the roof, *f*, and that roof, *f*, being hot, reverberates the heat on to the floor or bed, at the same time the heat which passes through the roof heats the ore in the upper chamber, *g*; and, in addition to such heat passing through the roof, the flame and heat from the furnace, having passed over the zinc ore, in the lower compartment of the apparatus, enters into and passes over the ore in the chamber *g*; and, in doing so, heats the roof *h*, of that chamber, and also the ore contained therein; and it will be seen that there is a third chamber *i*; the heat, therefore, which passes through the roof *h*, heats the ore in the chamber, *i*. In working this arrangement of calcined furnace or



apparatus, when the charge is withdrawn from the lower chamber, the charge in the chamber *g* is to be raked into the lower chamber through the openings for that purpose, which, at other times, are kept covered with fire-tiles, as shown in the drawing; and the charge in the chamber *i* is to be raked into the chamber *g*, and a fresh supply of ore charged into the chamber *i*.

ZINC.

part of this invention relates to a mode of arranging a series of retorts, and of applying heat thereto in the process of smelting or distilling zinc. According to the practice most generally pursued in smelting zinc, the heat is applied to the section of heat in crucibles, having descending iron pipes, which vessels containing water: all which is well understood, as well as the process of smelting or distilling zinc from the ore. Fig. 1587. is a side elevation of two sets of furnaces and retorts, arranged according to this invention, one of the furnaces being in section; and Fig. 1588. is a transverse section of the same, *a, a*, are a series of retorts of fire-clay, arranged, side by side, on a shelf of slabs or fire-tiles. These retorts are each closed at one end and open at the other, such open end being closed, when in operation, by a tile or door, *b*, fitting closely, and luted with fire-clay, as will readily be traced in the drawing. Each series of retorts is placed in a chamber, *c, c*, in such a manner that the heat and flame of the fire will pass from the fire-place or furnace, and act on one side



retorts; and having passed along all the series, will proceed to the upper chamber, *c, c*, and heat the other side of the retorts; and as the fires are urged by means of blasts of atmospheric air, the heat may be maintained with great advantage, and at comparatively small cost. The blasts of air produced by any ordinary blowing machinery, but rotatory blowers are preferred, the air may be cool or heated. When anthracite coal is used as the fuel, he prefers adopting the hot blast, at a temperature of at least 500° Fahr., heating may be performed by any of the well-known means now very resorted to for heating the blasts of air for smelting iron. *d, d*, are iron pipes ending from the retorts and entering into vessels containing water, similar to those at present in use for like purposes. Each chamber, *c*, is heated by its furnace or fire-place, which have openings, to be closed when at work; and in order to supply a supply of fuel to the fire, each fire-place has an inclined chamber, *e*, luted with fuel, and then closed air-tight by the cover, *f*, fitting into a sand-int, in order to prevent draught upwards. By this means the lower portion of fuel will be in an ignited state when at work. *g, g*, are a series of iron doors, leading to the mouth of each retort: these doors are capable of being removed by means of levers upwards, till the portions cut out at the sides come opposite the dips or *h*, when the doors may be removed, in order to get at the retorts. *i*, is a chamber in which the ore is heated previous to its being placed in the retorts. The nature of the brickwork, the construction and settling of the furnaces, being shown in the drawing, no further description need be given.

The inventor remarks, that he is aware attempts have been made to employ retorts for the smelting of zinc, and he does not, therefore, claim the same generally; but he claims, in respect to the third part of this invention, the mode of placing a series of retorts in a chamber, *c*, and causing the heat and flame to pass along, under and over, a series of retorts, as above described; and he also claims the mode of smelting zinc by blast, whether the heat of the fuel is caused to act on a series of retorts or in the manner shown, or on other arrangements of retorts or vessels, placed in a chamber or chambers.—*Newton's Journal, C. S.*, xxiii. p. 81.

PURIFYING, may be effected by melting the impure metal with lead in a deep iron pot, stirring them well together, skimming off the impurities, and covering the surface with charcoal to prevent oxidation, and keeping them in that state for three hours. The lead descends to the bottom by its greater weight, and leaves the zinc above, to be drawn off by a pipe in the side of the melt. This contrivance is the subject of a patent granted to Mr. William Godfrey in 1844.

CASTING. The costliness of bronze precludes its employment as a material for the purposes of monumental statuary almost entirely. On this account the art of sculpture, with the increase in the number of private collections, has been impeded. This impediment, however, is now being rapidly removed by the fact that have been made in the art of zinc casting. The working on this metal as for high art had at first to make good its progress against many prejudices, the part of artists themselves. In this lay the cause which long retarded its connection with sulphur, whereas, in domestic architecture, its application in the last eighteen years has superseded that of almost every other material. No doubt has now been dispelled as to the comparative durability of zinc in the open air, and under the influence of every variety of weather. Chemistry has demonstrated the property of the metal. It is readily melted, liquefies very completely, and therefore is better adapted to

cover the smallest lines in the mould than metals of a harder and more compact texture. The zinc casting is so pure and so finished, on being turned out of the mould, that the work requires but very little subsequent chasing. This circumstance, combined with the cheapness of the metal itself (the cost of a zinc cast being to a cast in bronze only one-sixth or one-eighth), renders zinc an admirable material for statuary. But the unfavourable colour of the zinc proved, for a long time, a great obstacle in the way of its application to these purposes.

This difficulty, however, through the indefatigable exertions of Mr. Kiss, the founder of this important branch of the art in Berlin, has been completely overcome. He has succeeded in imparting to the zinc a metallic surface, which gives to the cast the perfect aspect of Florentine bronze.

The colossal group of the "Amazon," after Kiss of Berlin, cast in zinc and bronzed by M. Geiss, presents a striking specimen of the perfection to which the latter has brought this peculiar invention.

The model of this group, cast in zinc by Geiss of Berlin, and lately deposited in the Great Exhibition, will establish the superiority of zinc over any other metal for similar purposes, so far as the elements of cheapness and solidity are concerned.

ZINC PRINTING. Representations of the different departments of the Imperial establishment, etched on zinc, chemityped and printed with the common printing press, — a new invention by Pul, for etching on zinc in a raised manner.

If this art be not calculated to supersede wood engraving, it can be applied with great advantage for certain purposes in the etching style, for maps, plans, drawings of machines, &c. A zinc plate is covered with an etching ground, the drawing etched in the usual manner with the needle, and bitten in. The etching ground is now removed, the deep lines cleaned with acid, and then the whole plate, in a warm state, covered with an easily fusible metal, with which, of course, the lines of the drawing are filled up. When the metal thus laid on is cold and firm, the whole plate is planed until the zinc appears again, and only the lines of the drawing remain filled with the fusible metal, which is easily distinguished by its white colour from the gray of the zinc. The whole plate is now etched several times; the former lines of the drawing, filled with this easily fusible negative metal, are not affected by the acid, while the pure zinc is eaten away. In this manner a drawing for printing in the copper-plate press can be converted into one in relief for use in the ordinary printing press.

ZINKING OF IRON. Iron may be conveniently coated, in the humid way, by a solution of sulphate of zinc, or one of the double salt of chloride of zinc and sal ammoniac, as now used in soldering and welding. To secure success, the zink solution should be weak, and only a weak galvanic current should be used, otherwise the zinc precipitated will again separate from the iron in scales. With proper precautions the deposit may be made as thick as strong paper. The article must be well cleansed before undergoing the operation.

The sulphate is prepared by saturating with sulphurous gas as much hydrate of carbonate of zinc, recently precipitated, as it will dissolve. For the compound salt, dissolve one part of zinc in hydrochloric acid, and to this solution add one part of sal ammoniac. Evaporate the liquor, and crystallize. The crystals are colourless six-sided prisms, translucent, easily soluble in water, and very deliquescent.

Zinked Iron weldable. — With a view to put this question to the test of experiment in the most severe manner, a piece of zinked iron wire rope was welded up into a bar, by Mr. James Nasmyth. In the first place it was found, that although the iron wire was quite covered with metallic zinc, which, although partially driven off in the process of welding, yet, so far from the presence of the metal, or its oxide, presenting any impediment to the welding of the iron (as in the case of lead), the iron wire welded with remarkable ease; and the result was a bar of remarkably tough, silvery-grained iron, which stood punching, splitting, twisting, and binding, in a manner such as to show that the iron was not only excellent, but, to all appearance, actually improved in quality in a very important degree.

Encouraged by such a result, a still further, and even more severe, trial was made, viz. by welding up a pile of clippings of galvanised iron plates, or sheet iron, covered with zinc, as in the former experiments. The presence of the zinc appeared to offer no impediment to the welding, and the result was a bloom or bar of iron, the fracture of which presented a most remarkable and beautiful silvery grain, as good, if not superior, in aspect to the very finest samples of "Low Moor" or "Bowling" iron. Blooms of this iron were rolled out into rods, and tested in the cable proving machine, and the result indicated from 5 to 10 per cent. higher strength than the best samples of wrought iron; thus establishing the fact, that,

so far from the presence of zinc being destructive to the strength and tenacity of wrought iron, the contrary is the case.

I may mention, that bars of iron were heated to a welding heat, prepared for sheathing, in the usual manner; and, on drawing them from the fire, for being welded, a handful of zinc filings was thrown on the welding hot surface, and the welding proceeded with. In this severe test no apparent impediment to the process resulted; the iron welded as well as if no zinc had been present. Judging from the appearance of the iron welded up from zinc covered iron scraps, not only as respects its clear silvery aspect, but also the increased strength which such exhibited under proof, it may not be unreasonable to infer, that some important improvement might be made in the manufacture of iron by the actual introduction of metallic zinc in some one or other of the stages of its manufacture, such as in the puddling furnace. What the nature of the action of the zinc is, we are not yet able to say; all we as yet know is, that, so far from being prejudicial to the quality of the iron, it appears to have rather an improving effect; and that to such an extent as to cause us to desire that the subject may receive the attention of some of our intelligent iron manufacturers, so as to put the matter to the test of actual experiment in the puddling furnace, or any other stage of the process, such as may appear to promise the best results.

I may name a curious corroborative fact, that the strongest cast-iron made in Belgium, and selected for the casting of guns, is made from an iron ore in which the ore of zinc forms a considerable portion. Whether the superiority of this iron is due to the presence of zinc is a question; but the result of the before-named experiments tends to lead to the supposition that such may be the case.

The small town of Stollberg, about four miles from Eschweiler, is a centre of great manufacturing activity. Perhaps the most interesting establishment for strangers are those for producing zinc from calamine. The best mines belong to the company of the Marquis de Sassenay, a French gentleman, who established here zinc works on a large scale, in which the following system is adopted:—

A chimney of considerable width, but of moderate height, stands in the centre of each batch of furnaces. In the middle, immediately adjoining the chimney, are two roasting furnaces, in which the ore is calcined. To the right and left of these are two pairs of reducing furnaces, or rather two large reverberatory furnaces, which are charged in the middle from above, and which are open at the side towards the gangways. In the space between the middle, or firing place, and these openings, are placed a series of retorts of fire-proof clay, of elliptical shape, into which moveable necks are inserted, that communicate with short perpendicular pipes, which fit into holes in the earthen plate, under which openings like an ash-pot are constructed. The ore having been well calcined in the roasting furnaces, and turned from a carbonate into an oxide of zinc, is first powdered. The oxide is then placed in the retorts, or muffles, as they are called; and the furnaces are carefully closed with clay, and highly heated to throw off the oxygen in the shape of gas. One result of the great heat in this process is that a large proportion of the metal escapes with the oxygen, which finds its way through the neck of the retort and down the tube connected with it, where the reduced metal falls in small globular particles. The metal thus deposited is washed from the refuse that falls from it, and is melted in furnaces placed at the extremity of the reverberatory furnaces. The heat of these serves to melt the zinc that it may cast into thin blocks for rolling into sheets. The production of these works is estimated at 10 tons per diem. For this, a consumption of seven times the weight of coal is required.

ZIRCON. See HYACINTH and LAPIDARY.

ZIRCONIA is a rare earth, extracted from the minerals zircon and hyacinth; it is an oxide of zirconium, a substance possessing externally none of the metallic characters, but resembling rather charcoal powder, which burns briskly, and almost with explosive violence.

THE END.

